ASTRONOMY

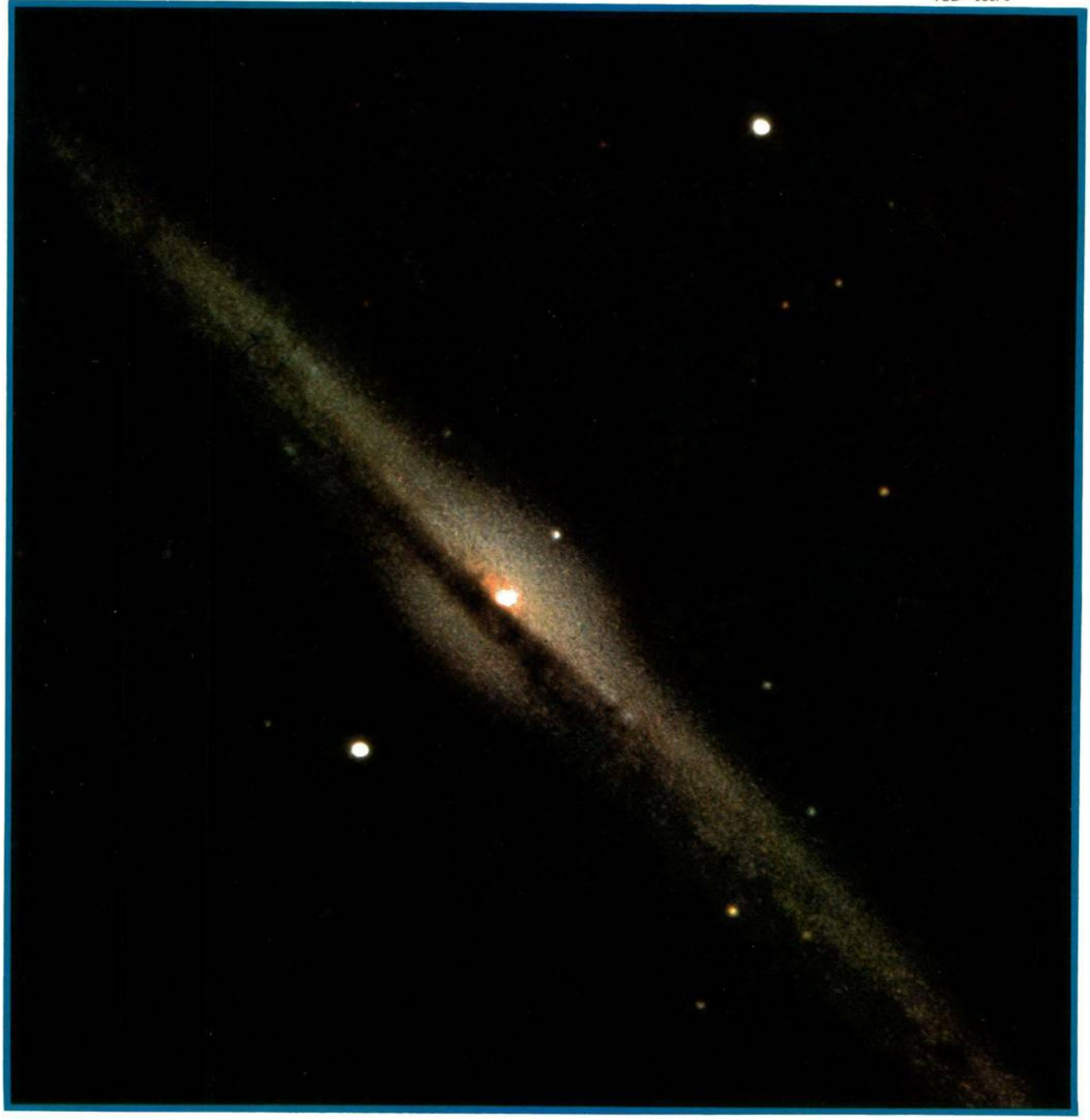
May 1985
U.S. $2
UK £1.50
Can. $2.50

When Stars Collide

Selling Comet Halley

Polar Alignment Made Easy

ICD# 08070



Spiral Galaxy NGC- 4565

Meade® Quartz S/C's:

Meade
QUARTZ
Meade
N
E
W
S
Quartz
Manual
Sidereal
Solar
Lunar
Drive
Corrector
Map
Dec
Power
12V.D.C.
Reticle
Reticle
Adjust
Meade
QUARTZ
LX DRIVE

Meade 8" Model 2080/LX3 and 10" Model 2120/LX3, with Quartz Electronic Drive Systems: the most advanced Schmidt-Cassegrains ever manufactured for the serious amateur. Consider these state-of-the-art features:

1 Certified Optics: All 8" and 10" LX3 optics are hand-matched, laser-tested, and individually certified in writing by Meade Instruments to yield the finest diffraction-limited Schmidt-Cassegrain performance obtainable from any manufacturer.

2 New Quartz Electronic LX Drive System: Ultraprecise quartz micro-electronics augment the superb Meade LX Worm Gear Drive, to achieve *true sidereal-rate tracking.* Input-frequency is accurate within ± .005% of the sidereal frequency, *independent* of ambient temperature and local power line frequency variations.

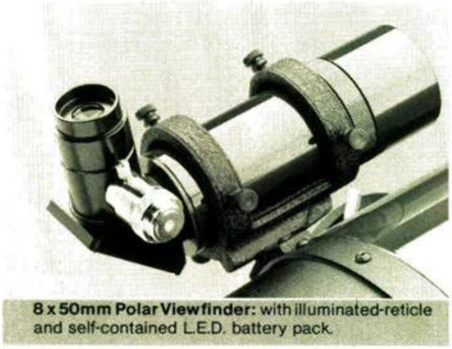
3 Plug-In Single- or Dual-Axis Drive Corrector Capability: No drive corrector chassis boxes to fool with! All electronics are completely self-contained within the LX3 drive base — just plug-in the optional R.A. or Dual Axis control box and use. In the Dual-Axis mode, the Declination motor plugs directly into a jack on the LX3's power panel.

4 A.C. Operation: A 25-ft. power cord with self-contained 115 volts A.C. converter is included with each 8" and 10" LX3 model, yielding 12 volts D.C. input to the telescope's power panel. A red L.E.D., located adjacent to the power input jack, indicates proper power connection.

5 Field Operation: Meade LX3 models operate from 12 volts D.C. and may be powered *directly* from your auto cigarette lighter plug, using the standard-equipment D.C. power cord — *no drive corrector or inverter unit is required for field operation!* LX3 models may even be independently powered in the field, away from your automobile, with the optional Meade Power Cell.

6 Power Panel Output Jacks: The Meade 12mm Illuminated Reticle Guiding Eyepiece and red L.E.D. Map Light plug directly into jacks provided on the power panel, eliminating the need for separate battery packs.

7 8 x 50mm Illuminated Reticle Polar Viewfinder: The illuminated, precisely-etched reticle scale permits extremely accurate polar alignment.



8 x 50mm Polar Viewfinder: with illuminated-reticle and self-contained L.E.D. battery pack.

The Meade 8" Model 2080/LX3: The next generation S/C from the World Leader.

8 Equatorial Wedge with Magnetic Compass, Latitude Scale, Bubble Level, and Micrometric Azimuth Control: This Meade exclusive facilitates *fast, easy* polar alignment even if the Pole Star is not visible from your observing location.

9 Piggyback Camera Bracket: This useful accessory, again included with all LX3's, attaches directly to the telescope's rear cell, for wide-field astrophotography using your 35mm camera.

10 Multi-Coated Diagonal Prism: The Meade Multi-Coated diagonal yields the highest light transmission (over 98%) of any production diagonal available, mirror or prism.

11 High Transmission (MgF_2) Coatings on the Correcting Plate: These coatings substantially increase correcting plate light transmission throughout the visual spectrum.

12 Optional Multi-Coated/Silvered Optics Group: *The revolutionary MC/SO Group achieves virtual maximization of transmission/reflectance on every optical surface, and increases total light transmission by approximately* **23%** *over standard Meade 8" and 10" Schmidt-Cassegrains.* The Group includes (1) Multi-Coated aluminized primary mirror; (2) Multi-Coated silvered secondary mirror, in place of standard-aluminized mirrors; and (3) Multi-Coated correcting plate in place of standard MgF_2 coatings (item 11 above).

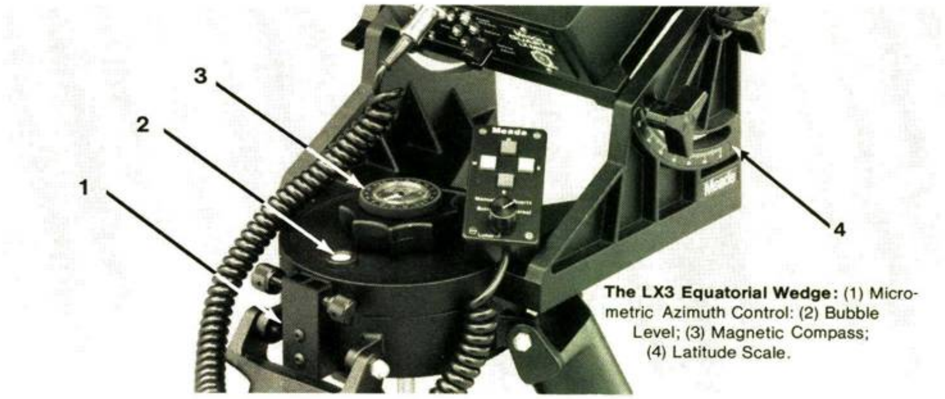
13 Audio Cassette: This useful tape, provided with every LX3 telescope, explains in detail the features, set-up, and applications, both visual and photographic, of your telescope.

14 Lifetime Warranty: Meade 8" and 10" LX3 Schmidt-Cassegrains, excluding batteries, *are warranted for life* in the U.S.A. and Canada. See the Meade General Catalog for details on this warranty — the most extensive in the industry.

The Quantum Leap.

The best news of all . . . Meade LX3's are priced competitively with other Schmidt-Cassegrains offering only a fraction of the LX3 features. Discover them now at your Meade dealer. You'll see why Meade Instruments is the World's leading manufacturer of astronomical telescopes for the serious amateur.

And the first to make a true Quantum Leap in Schmidt-Cassegrain technology.



The LX3 Equatorial Wedge: (1) Micrometric Azimuth Control: (2) Bubble Level; (3) Magnetic Compass; (4) Latitude Scale.

U. S. and Canada Dealer Locations & Assistance

For your nearest Meade dealer location, or for free telescope information and assistance, call Meade Instruments **toll-free** from anywhere in the continental U.S.A, (except Calif.):

1-800-854-7485

From all other areas, including California, call direct: **(714) 556-2291**

Complete 52-Page General Catalog - $3.00

Send $3.00 for your copy of the Meade full-color **General Catalog #85C,** with many astrophotos through Meade telescopes and complete details on the entire range of Meade precision astronomical telescopes, spotting scopes, telephoto lenses, and accessories. Meade General Catalogs are forwarded by return First Class Mail.

Meade Instruments Corporation
1675 Toronto Way, Costa Mesa, Calif. 92626 ☐ (714) 556-2291

© 1985

ASTRONOMY

Vol. 13, No. 5 May 1985

The World's Most Beautiful Astronomy Magazine • Established by Stephen A. Walther

Editor-in-Chief
Richard Berry
Managing Editor
Katherine Bond
Art Director
Thomas L. Hunt
Senior Editor
Robert Burnham
Assistant Editors
David J. Eicher
Francis Reddy
Assistant Art Director
Jane Borth Lucius
Typographer
Mary MacAdam
Art Assistant
Susan R. Myers
Editorial Assistant
Diane Kendzie-Holdaway

President, AstroMedia Corp.
Robert A. Maas
Advertising Coordinator
Dana-Lynne Terry
Accountant
J.L. Peters
Product Manager
Susan Poole
Circulation Director
Kristie Fischer
Circulation Manager
Rosemary L. Pickart

Adv. Rep., NE Region
Adpress, Inc.
New York, NY 10016
(212) 679-1710
U.S. Newsstand Distribution
I.C.D., The Hearst Corp.
New York, NY 10019
Canadian Newsstand Dist.
Distr. Div. of TV GUIDE
Toronto, Ontario M4S 3B3
World Newsstand Distribution
Boarts International, Inc.
New York, NY 10019

6 **Ancients of the Universe: Globular Clusters**
by Gail O. Clark

14 **Celestial Pinwheels: Spiral Galaxies**
by Barry Parker

Forum 24 **Selling Comet Halley**
EPP-sih-lon AWE-rih-gai

In Focus 32

Behind the Scenes 33

Photography in Astronomy 35 **Southern Schmidt Photos**
by Stephen Edberg

Astronomy Reviews 39

Eye on the Sky 42 **Saturn Comes to Opposition**
by Fred Schaaf

Equipment Atlas 51 **How to Use a Polefinder**
by Paul J. Burke

AstroNews 58

AstroMart 61

AstroCalendar 62

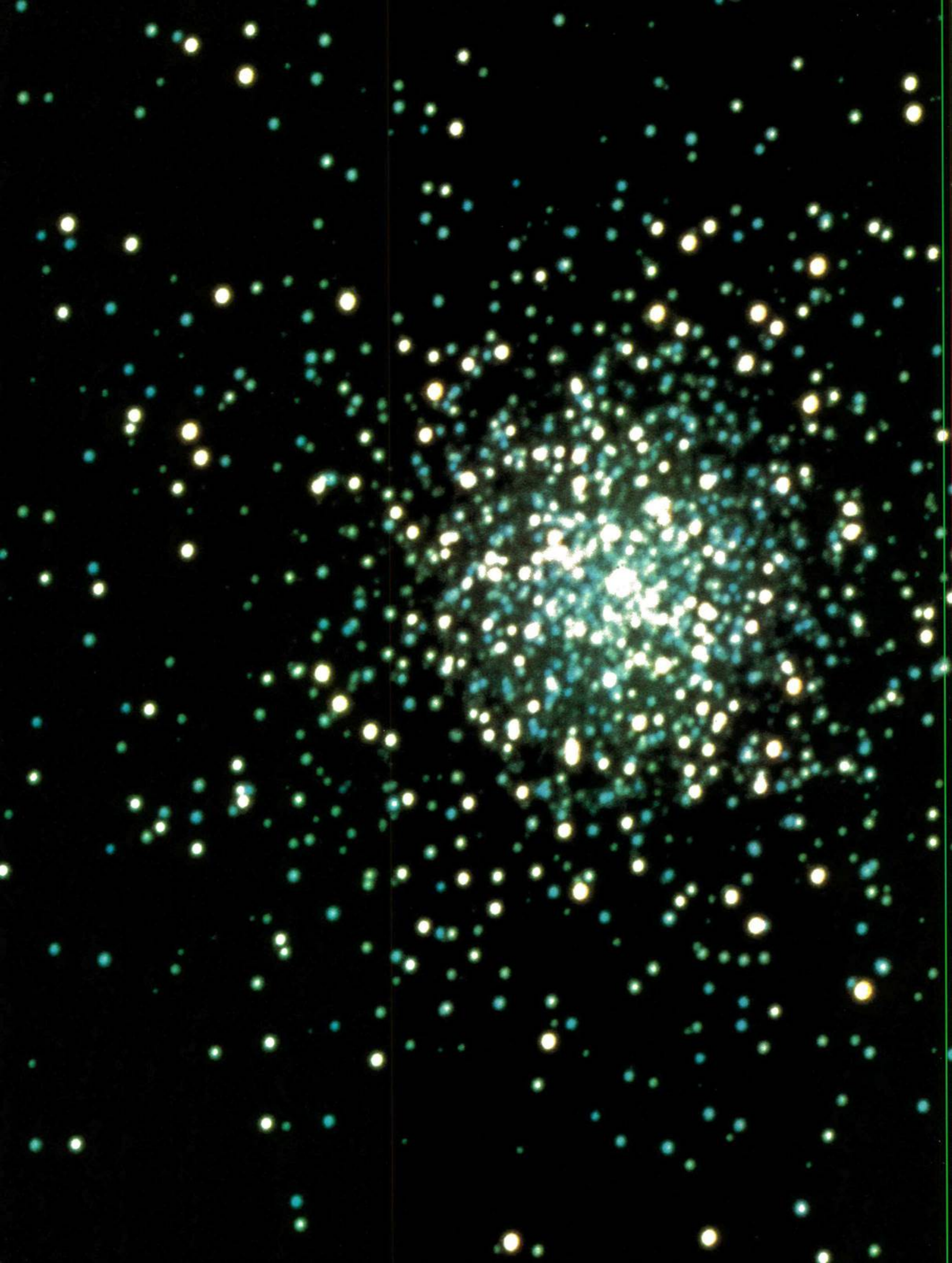
Stellar Frontiers 67 **When Stars Coalesce**
by Ken Croswell

Gazer's Gazette 75 **Observing the Apollo 17 Landing Site**
by Herbert Holder

The Backyard Astronomer 78 **Canes Venatici**

Cover: If we could travel about a million light-years from the Sun in the direction of Auriga and look back at the Milky Way Galaxy, this is roughly what we'd see. A thin line, dark with dust, traces the galactic plane, while a yellow center marks the nucleus. On these pages, we see a spiral galaxy tipped to display its gracefully curving arms. This month ASTRONOMY explores why a galaxy like the Milky Way has spiral structure and takes a look at some of its oldest inhabitants, the globular clusters. Cover: NGC-4565; these pages: M-106. Photos courtesy U.S. Naval Observatory.

ASTRONOMY (ISSN 0091-6358) is published monthly by AstroMedia Corp., 625 E. St. Paul Ave., P.O. Box 92788, Milwaukee, WI 53202. Copyright © 1985 AstroMedia Corp., all rights reserved. Material in this publication may not be reproduced in any form without permission. Second class postage paid at Milwaukee, WI and additional mailing offices. POSTMASTER: Send address changes to ASTRONOMY, P.O. Box 92788, Milwaukee, WI 53202. Questions about subscriptions and product orders: **(414) 276-8547** weekdays, 8am - 4pm. Allow six to eight weeks for new subscriptions and changes of address. New subscriptions start with current issue. Subscription price: 1 year, $21.00. All foreign: add $5.00 per year; please remit in U.S. funds. Send editorial and business inquiries and submissions to the address above. Telephone: (414) 276-2689. Not responsible for unsolicited materials. AstroMedia staff: Patricia Adams, Sherrie Burns, Mercy Domena, Merlene Edwards, Wendy Graika, Erica Jensen, Maggie Martinez, Susan Robinson, Sandy Timmons, Deborah Wicentowski. ASTRONOMY is indexed in *The Reader's Guide to Periodical Literature*. Microfilms of ASTRONOMY available from University Microfilms, Inc., 300 N. Zeeb Rd., Ann Arbor, MI 48106 and Bell & Howell Company, Old Mansfield Rd., Wooster, OH 46691. Printed in the U.S.A.

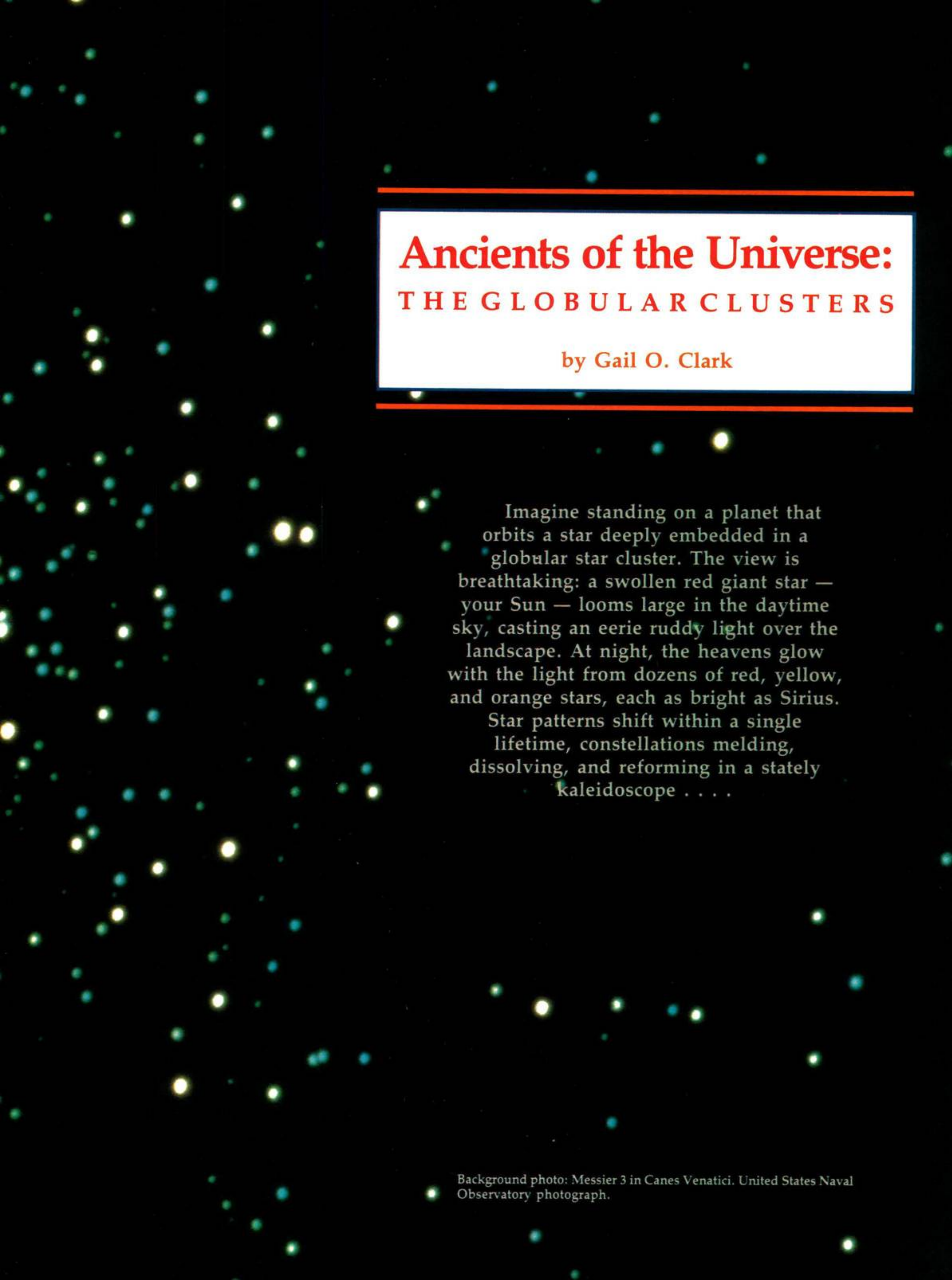


Ancients of the Universe:

THE GLOBULAR CLUSTERS

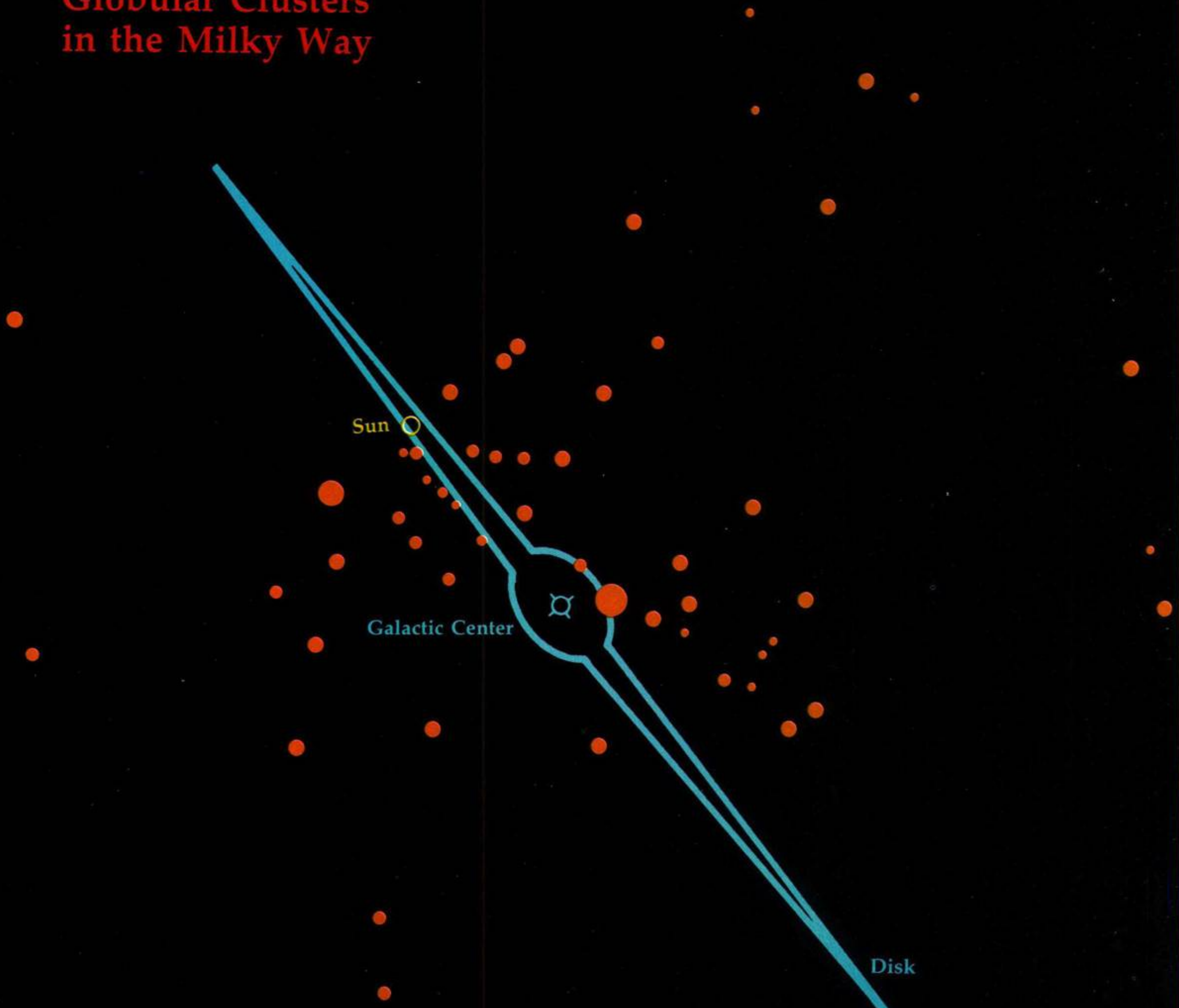
by Gail O. Clark

Imagine standing on a planet that orbits a star deeply embedded in a globular star cluster. The view is breathtaking: a swollen red giant star — your Sun — looms large in the daytime sky, casting an eerie ruddy light over the landscape. At night, the heavens glow with the light from dozens of red, yellow, and orange stars, each as bright as Sirius. Star patterns shift within a single lifetime, constellations melding, dissolving, and reforming in a stately kaleidoscope . . . .

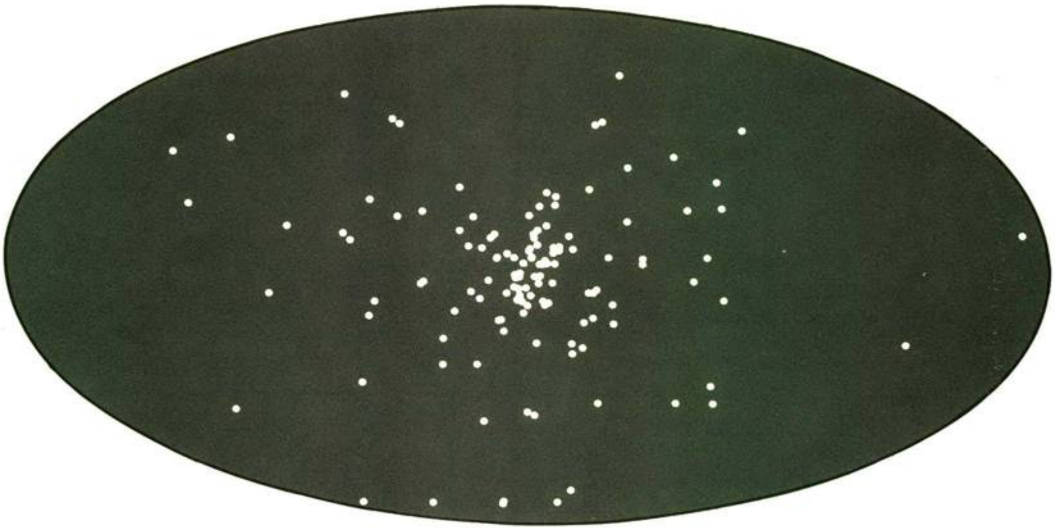


Background photo: Messier 3 in Canes Venatici. United States Naval Observatory photograph.

Globular Clusters in the Milky Way


Sun
Galactic Center
Disk

If we traveled outside of the Milky Way Galaxy, we would see that its globular clusters are distributed rather evenly in a halo about the galactic center.



But from inside the Milky Way looking out, we see globular clusters lumped together in one broad region of sky. In this all-sky view, these clusters are visible in large numbers only when we look in the part of the sky toward the center of the Galaxy.

For Earth-bound astronomers, the term *globular cluster* evokes a pleasingly symmetrical image of a ball, a globe, that contains hundreds of thousands of stars tightly packed in its core and loosely dispersed around its periphery. Any observer can recall the brightest of them: M-13 in Hercules, Omega Centauri, M-22 in Sagittarius, M-4 in Scorpius, 47 Tucanae, M-3 in Canes Venatici, and M-5 in Serpens.

But the true nature of globular clusters long eluded such simple summarization. First recognized in 1786 by the indefatigable observer William Herschel, globular cluster was the name he gave to a particular class of "nebulae" — the fuzzy patches in the sky he systematically sought and catalogued. In his 48-inch telescope — then the largest in the world — some nebulae appeared round and, under conditions of excellent seeing, were partially resolvable into individual stars. From their distinctive shape, he called them "globular clusters" and logged 33 of them.

After Herschel and throughout the 19th century, astronomers learned nothing more about globulars than what a human eye could discern by looking through a telescope. They were round — some more so than others — and they often had tendrils of stars running out to the limit of visibility. They usually stood alone in space away from the Milky Way and other stellar groups.

Yet astronomers soon noted one curious fact: globulars are not placed around the sky at random. Although they are found at almost every galactic latitude, nearly all congregate in about 120° of galactic longitude. (In fact, one famous photograph covering two percent of the sky shows a third of all known globulars.) In short, virtually every globular cluster lies on one side of the sky. William Herschel's son John noticed this and declared that "it cannot be coincidence." But the grand design remained hidden during the rest of the 19th century and well into the 20th.

By the time of the First World War, photography had given astronomers a large library of globular cluster images in which individual stars could be seen and their brightnesses measured. In the second decade of this century, astronomer Harlow Shapley began his study of the variable stars in globular clusters. Working at Mount Wilson Observatory in California, he investigated the periods of variation and the apparent brightnesses of Cepheids and their more luminous cousins, the RR Lyrae stars.

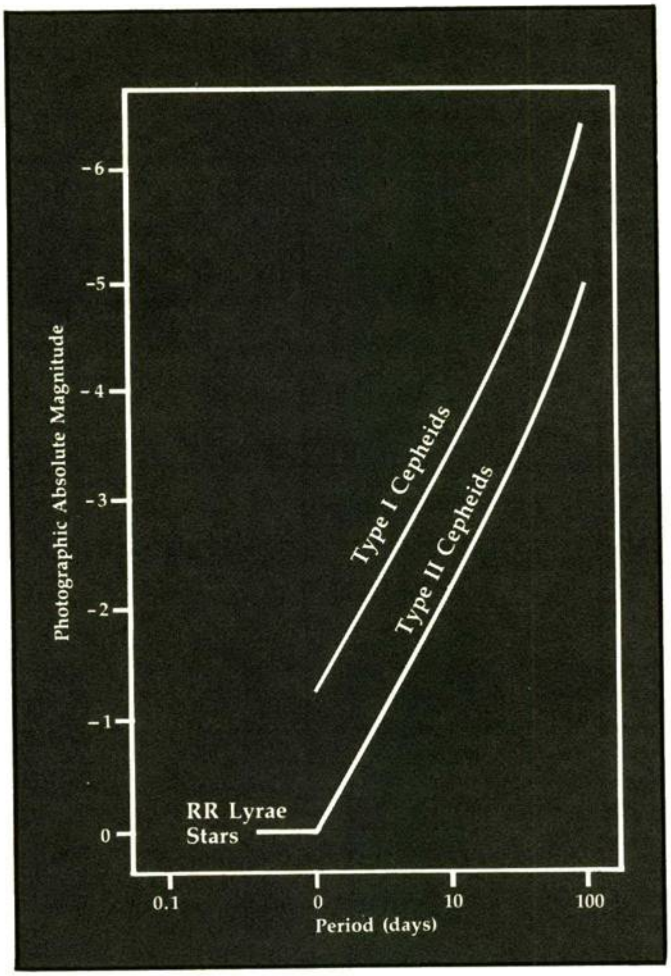
Cepheids have a valuable property: their period of variation and their intrinsic brightness are related — the longer the period, the brighter the star. In addition, astronomers had learned that all RR Lyrae stars have about the same intrinsic brightness. By comparing the intrinsic brightness of a variable (in the case of a Cepheid, deduced from its period) with its apparent brightness recorded on a photographic plate, Shapley derived a distance to each of the globular clusters. He erred by lumping all Cepheids together (there are two distinct types) and by ignoring the dimming effects of interstellar dust, but the overall idea was sound and the results he obtained have never been called into serious question from that day to the present.

The newly-derived distances to the globulars, coupled with their celestial coordinates, led Shapley to uncover the basic form of the Milky Way Galaxy. The Galaxy contains a flat broad disk with a bulging nuclear region at its center; surrounding the nucleus is an extended halo of globular clusters. The halo of globulars is a natural result of their eccentric, million-year-long orbits of the galactic nucleus. They are compelled by orbital mechanics to spend most of their time far away from the disk of the Galaxy. And, concluded Shapley, the reason we see them all on one side of the sky is that the Sun itself lies more than halfway toward one edge of the Galaxy.

With their distribution in the Galaxy established, globular clusters soon attracted a different kind of attention from observers. Astrophysicists began to investigate them as individual objects. What sort of stars do they contain? How old are they? How do they relate to the history of the Galaxy? From the answers to these questions, a composite profile of a typical globular cluster emerged.

The average globular possesses tens of thousands to a few millions of stars — roughly a millionth the mass of an average spiral galaxy. It can measure from 15 to 300 light-years across — again, a tiny fraction the size of a galaxy. The density of stars in a globular ranges from very loose at the edges to greatly concentrated in the core, where as many as 300 stars can be packed into a cubic light-year — a thousand times that found in the neighborhood of the Sun.

Globular clusters lack the hot young stars found in the Galaxy's spiral arms. The brightest stars of a globular are red giants — cool, ancient stars well along the path toward stellar senility. This offers a further clue to their



A color-magnitude diagram for the globular star cluster Messier 3. This array plots the stars by their color (horizontal axis) versus their magnitude (vertical). The faintest stars are main-sequence stars much like the Sun, but the bulk of cluster stars lie in the subgiant branch. At top right are the red giants — the most luminous stars within the cluster. The box at left is the so-called RR Lyrae gap, the region in which these stars occur. After H.L. Johnson and A.R. Sandage.

The period-luminosity relationships for both classes of Cepheids and for RR Lyrae variable stars. By gauging a variable star's apparent brightness against known standards in the period-luminosity relationship, astronomers can measure the distance to a globular or galaxy containing these stars.

origin: the lusty saga of star birth, ever-renewed in the galactic disk, has apparently reached its end in globulars. Born from the same clouds of primordial matter as the Galaxy, the stars in the globular clusters are essentially without offspring — they are the last of their line.

To understand how two groups of stars, both with the same initial chemical content and differing mainly in size, could follow such markedly different evolutionary tracks, we must back up a bit and see what happened to the Galaxy as a whole after it formed. The first generations of galactic stars began with essentially the original mixture provided by the creation of the universe in the "Big Bang" — hydrogen and helium with trace amounts of heavier elements, called "metals" in the jargon of astrophysicists.

But this primordial mix couldn't remain unchanged for long, since every star is a sort of self-powered alchemist's furnace. A star begins by fusing hydrogen into helium, then fuses helium into carbon, followed by carbon into oxygen, and so on with as many changes of fuel as the star's mass allows. Some of these "metals" will eventually be scattered into interstellar space, either by supernova explosions from the massive stars, or by planetary nebulae and vigorous stellar "winds" blown from their smaller brethren.

The end result is that the interstellar medium is progressively enriched by heavy elements "cooked" in the fusion furnaces of stars. Interstellar matter is the raw stuff from which the next generation of stars form — and clearly each new generation begins life with a richer mixture than the previous generation. Whereas the first stars contained essentially no metals, stars which formed more recently — the Sun, for example — have a metal content of about 2.5 percent.

The galactic nucleus is very different: it contains old red stars and little dust or gas. It seems to be relatively quiescent, with stellar formation only a distant memory; the stars in it have a metal content of only about one percent. The composition of the galactic center, in fact, is startlingly like that of a super-sized globular cluster. Let's look at each extreme: the largest globular clusters — found in outer haloes of giant elliptical galaxies — and the very smallest dwarf elliptical galaxies. Both are remarkably similar in content and differ in size only by a factor of 10 or so. Why are the nuclei of spiral galaxies surrounded by disks of star-forming regions, while globular clusters have none? No one knows the answer, but it may be that globular clusters simply don't have enough mass.

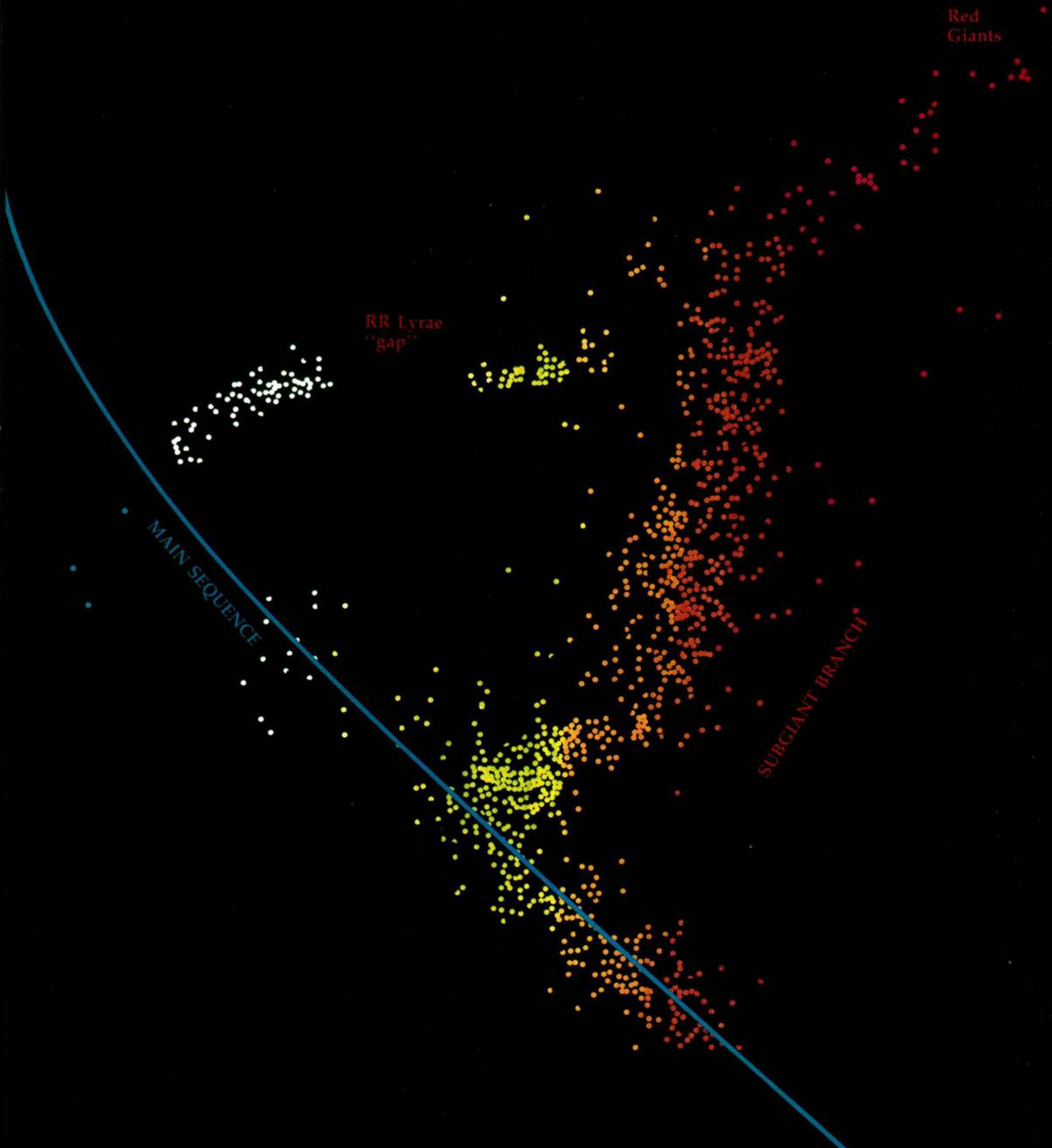
The great dissimilarity between the nuclear region and disk of the Milky Way led astronomer Walter Baade to conclude in 1944 that spiral galaxies have two populations of stars. The stars of the disk he called Population I: to those of the nucleus he assigned the name Population II. Population I objects are young, metal-rich, and generally quite bright. Population II stars are older, redder, and metal-poor. These stars fill globular clusters as well as the galactic nucleus.

One reason globulars differ so much from the disks of the galaxies they belong to may be that they are cut off from the normal give-and-take of stellar formation in the hurly-burly of the galactic disk. Alone and self-contained, globulars only grow older.

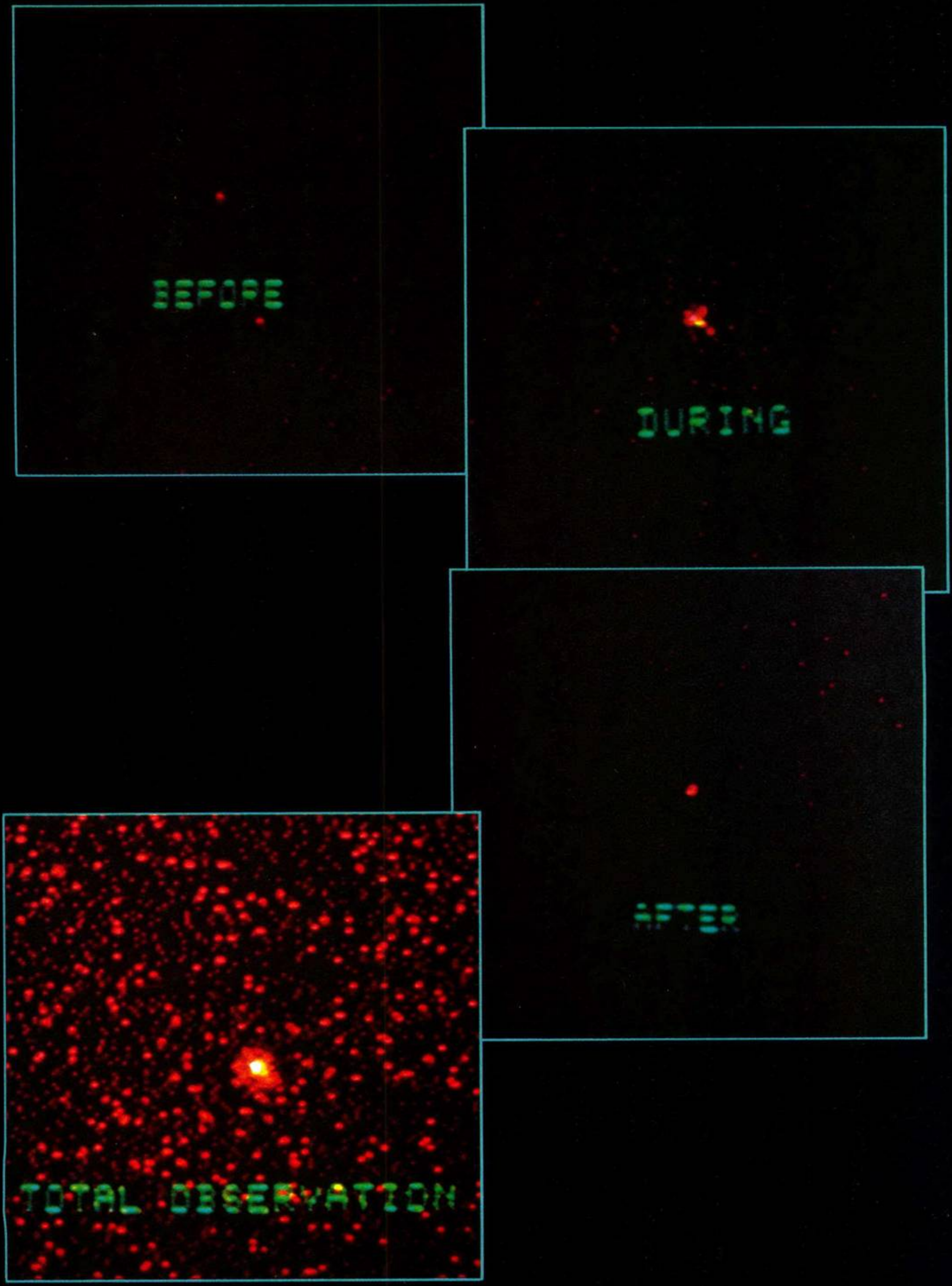
Yet even old stars like those in a globular must shed material as they age. Though they lack the many generations of stars found in the disk, they ought to teem with debris — the by-products of their first generation of stars. Where is it? Why hasn't it formed new stars?

Two factors prevent globulars from recycling their debris. Globulars are still much smaller than the tiniest dwarf galaxy. Globulars thus have fewer resources and their total output of enriched material is too small to sustain on-going star formation. Second, and this could be the decisive factor, globulars can't even hang onto what material they do produce long enough to make stars from it. Every few hundred million years or so, each globular swoops through the plane of the Galaxy. There, interaction with the greedy stars and dust clouds of the disk swiftly strip the globular of all its loosely bound material. The

Color-Magnitude Diagram for Messier 3

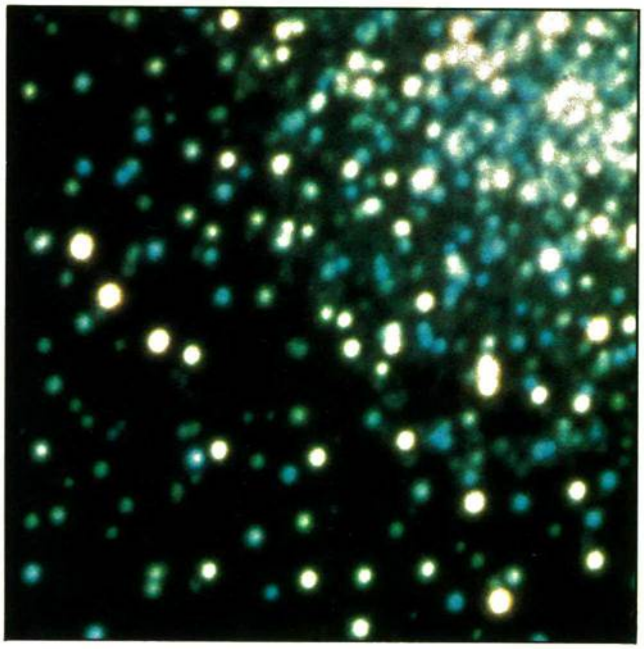


X-Ray Burst From Globular Cluster Terzan 2


BEFORE
DURING
AFTER
TOTAL OBSERVATION

In 1976, astronomers began detecting X-ray pulses from the centers of globular clusters. This image of the cluster Terzan 2, made with NASA's orbiting Einstein Observatory in 1978, shows a high-energy burst of X-ray emission. Is this material falling onto a hot neutron star, or does the X-ray emission indicate stars are being pulled into a black hole? NASA photo.

What good are globular clusters in understanding the universe? Since they formed about the same time as the disk of the Milky Way, their composition as a whole and the way in which their member stars behave offers us unique insights into the ancient past — and the distant future. U.S. Naval Observatory photo.



cluster is then sent back to the galactic outskirts, with its enriched material removed and its stellar population unrejuvenated. A globular may also lose a number of its least massive stars during such an encounter. As if this weren't enough, inside the globular itself hot stellar winds from the largest cluster stars drive away much of the interstellar material. Globulars, it seems, are "programmed" to be sterile, unproductive members of galaxies.

But the story of globular clusters is not simply a dismal tale of elderly stars winding down toward death. Recently, several globulars have proven to be powerful X-ray sources. Astronomers first detected the pulses of high-energy radiation in 1976, and theorists have been trying models to explain the phenomenon ever since. The X-ray bursts rise from nothing to tremendous levels of energy in just a few seconds, implying a compact source. Some astronomers believe that binary star systems deep inside the globulars are responsible: in such a system, a neutron star could draw gas from a supergiant companion and heat the gas to extreme temperatures, releasing X-rays. Others believe the X-rays are the final "screams" from superheated stars falling into a giant black hole at the globular's center. Though no firm answers are in sight, studies at high-energy wavelengths promise to reveal a lot about the central engines of globulars.

In our Galaxy, 131 globulars have been catalogued, including several so remote they were long considered extragalactic. Shapley called about a dozen remote globulars "intergalactic tramps," thinking they might eventually wander off to join other galaxies. Recent models of our Galaxy, which include an enormous corona of dark material, rule this out. The unseen mass from a galactic corona means that even extremely distant globulars fall well within the Milky Way's gravitational influence. A globular in Sextans called Palomar 3 may currently be the most distant object in our Galaxy, lying 425,000 light-years from the Milky Way's core and 330,000 light-years from the Sun. It measures a whopping 350 light-years across, more than twice M-13's diameter of 120 light-years.

From our frame of reference here on Earth, globular clusters generally lie in an area of sky between 5 degrees and 20 degrees from the glimmering band of Milky Way. Though we know of 131 clusters, there are probably over 100 more hidden by obscuring clouds of dust and gas toward the galactic center. It seems likely that the total number is around 300.

Until now, we've considered globular clusters in spiral galaxies, particularly in our Milky Way. What about other galaxies? Unfortunately, research on globular clusters in galaxies other than our own is in a rather early stage. The great distances to other galaxies preclude our learning much about them. We certainly can see globular clusters in other galaxies, however. For example, in the Large Magellanic Cloud, some 172,000 light-years away, several globulars appear to be much bluer than any known in our Galaxy. This suggests that they are younger than most globular clusters, but are they? At 2.2 million light-years, the Andromeda Galaxy — a spiral much like our Milky Way — has a halo of dozens of globulars much like our Galaxy. In fact, some M-31 globulars are bright enough to be seen with backyard telescopes. If we move out to the Virgo cluster of galaxies 60 million light-years away, we see an inviting variety of galaxies — but the largest globular clusters are tiny, star-like glows whose nature remains largely hidden.

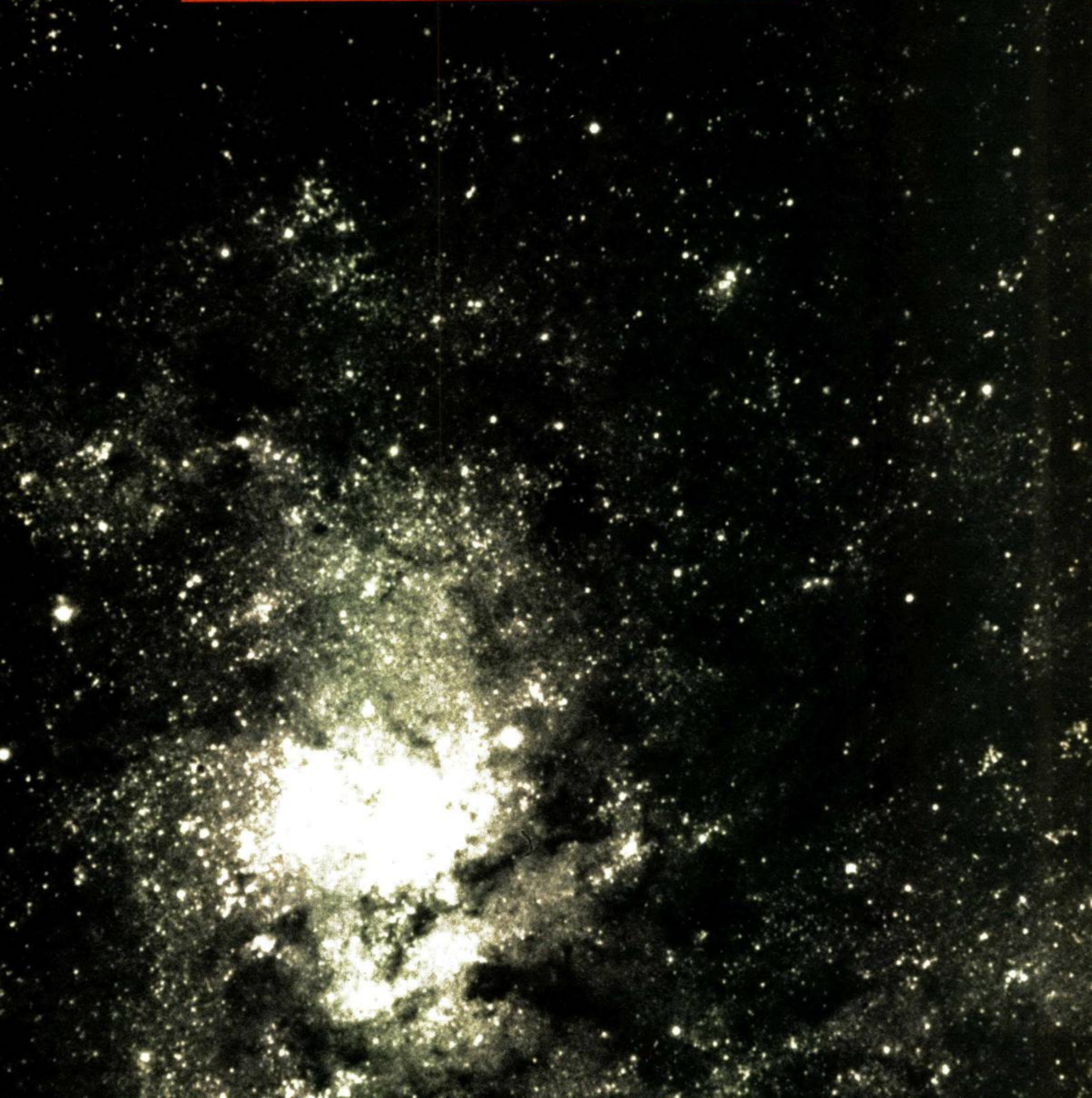
What of the future for globular clusters? As they slowly swing about the center of the Galaxy, periodically being purged of their interstellar gas, these huge swarms of ruddy stars may last nearly forever. As eons pass, many of the red giants will puff away their atmospheres into space and transform into white dwarf stars. The white dwarfs will continue to orbit, while calmly radiating their heat into space. Ultimately, globular clusters are destined to include large collections of burned-out white dwarfs — cosmic cinders that mark the spots of once active star colonies. Billions of years from now, globulars will glow dimly with the deep red light of their only survivors — thousands of tiny red dwarfs which formed when the universe was young. They have burned at a slow, steady rate ever since, and will continue to gracefully fuse hydrogen into helium, and helium into carbon just as they have since the beginning. Globular star clusters are indeed the Ancients of the Universe.

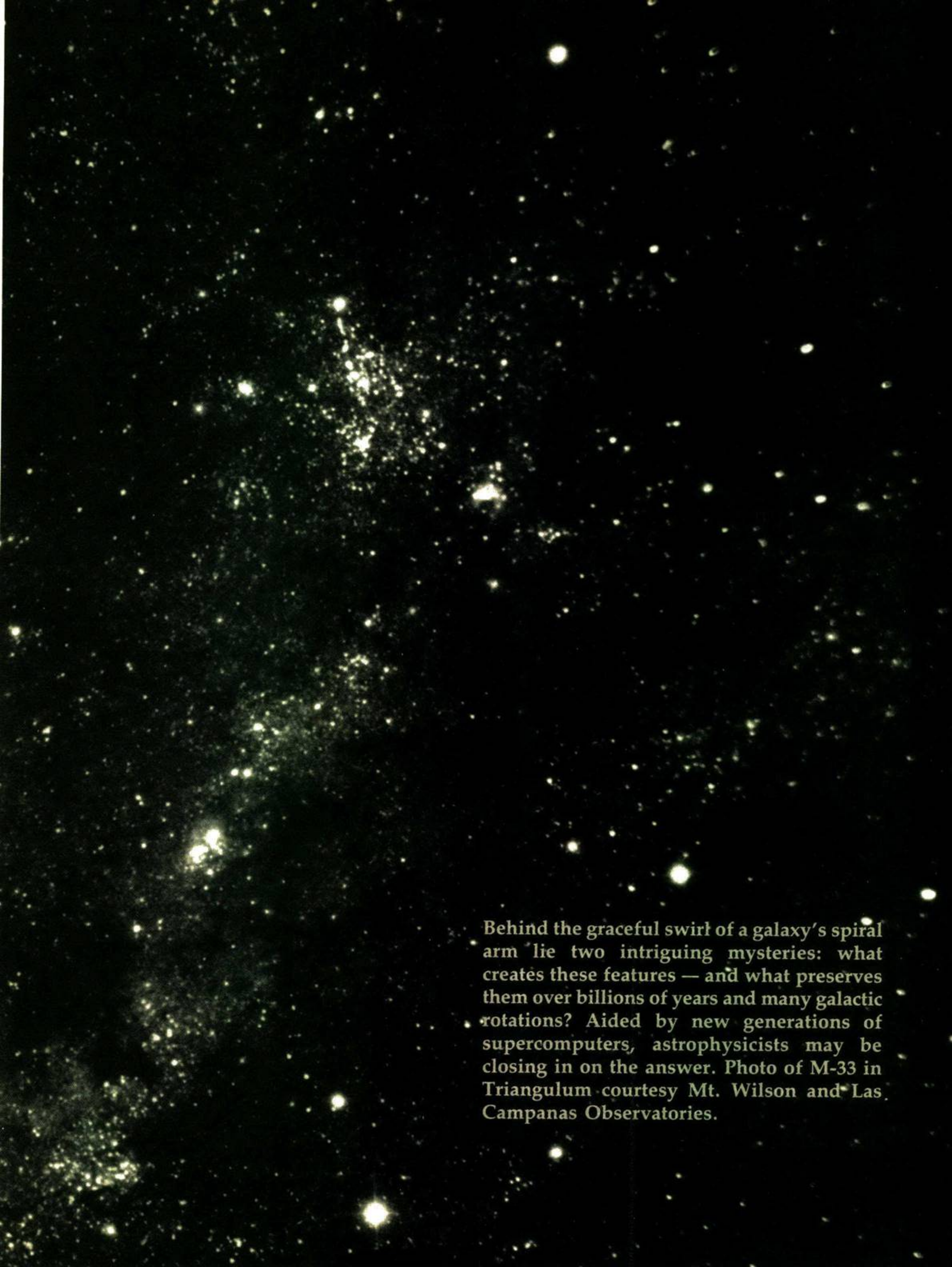
Gail O. Clark is a freelance writer and dedicated observer. His last article was "Discover the Pleiades" in the November 1983 issue.

Celestial Pinwheels:

THE SPIRAL GALAXIES

by Barry Parker





Behind the graceful swirl of a galaxy's spiral arm lie two intriguing mysteries: what creates these features — and what preserves them over billions of years and many galactic rotations? Aided by new generations of supercomputers, astrophysicists may be closing in on the answer. Photo of M-33 in Triangulum courtesy Mt. Wilson and Las Campanas Observatories.

Spiral galaxies are among the most beautiful objects in the universe. With vast arcing arms that echo the convolutions of a seashell, each is a tangled tract of stars, gas, dust, and other debris so huge it would take over a thousand human lifetimes for a beam of light to crawl from one edge to the other.

Galaxy after galaxy, each seems as different and individual as the people that populate our planet. Some galaxies have loose trailing arms, some are tightly wound, and some have strange bar-like structures at their centers. Our perspective of them also varies: some face us directly, others tip at an angle, and a few are edge-on slivers of light.

Yet when we look at a spiral galaxy, we are deceived. Most people would swear that almost all its stars lie in the spiral arms. Look at the photo on pages 14 and 15. Wouldn't you agree? Yet this isn't really what's happening — the spiral arms are prominent only because they contain large numbers of luminous young giant stars and a considerable amount of glowing gas. In between this show-off minority lies a vast hinterland of lesser lights, whose cumulative effects may be even more important.

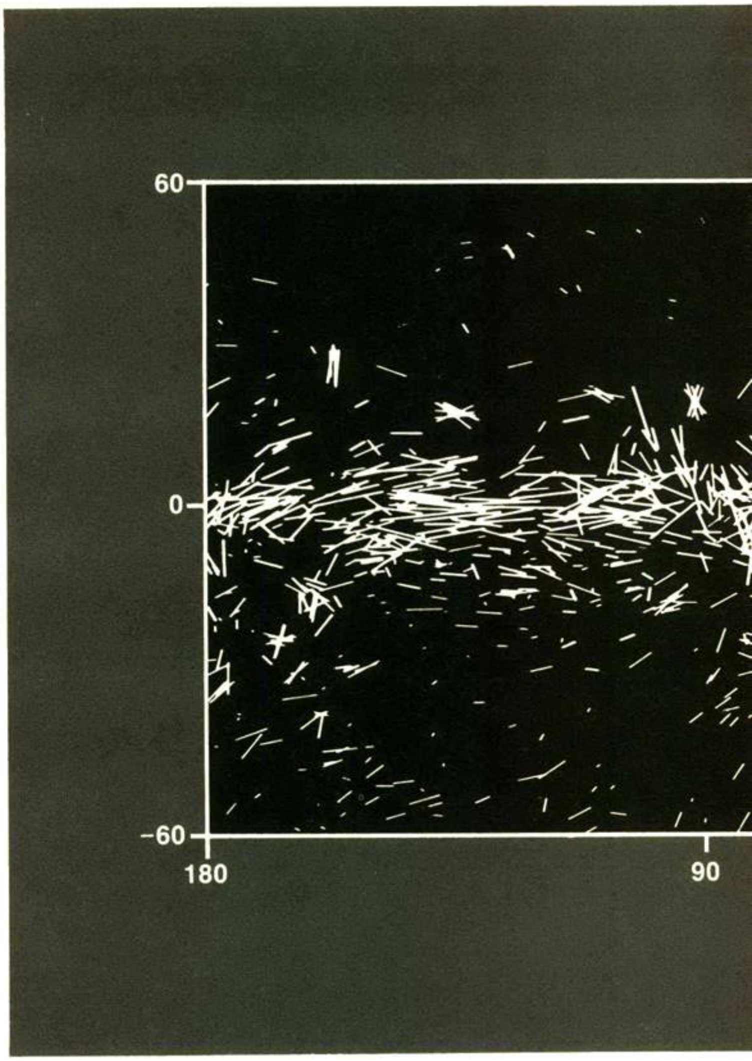
What, then, *is* a spiral galaxy? The raw ingredients are 100 billion stars rolled out in a sheet approximately 100,000 light-years across. Bluish arms form a spiral galaxy's most recognizable feature, but anywhere from a quarter to a half of its material may lie in the yellowy nucleus — a bulging region of old (mostly red) dwarf stars at the center of the many-armed disk. The placid appearance of the dense, star-packed nucleus is also highly misleading: it is the most active region in any galaxy and the site of the most violent explosions in the universe. Even seemingly docile galaxies like our own Milky Way display evidence of substantial core activity.

Though you could spend years watching or photographing a spiral and never see the slightest movement, it is there. Like pinwheels on a gentle puff of wind, they cartwheel lazily about their center. Why they rotate, we don't know. It is a property that each received somehow from the Big Bang explosion that created the universe. Though we cannot see the spin, we can measure it via the Doppler shift: careful examination shows the spectral lines from the receding side of a galaxy are red-shifted, while those from the approaching side are blue-shifted.

Where do spiral arms come from? This has puzzled astronomers almost since galaxies were discovered. Breakthroughs have been made in past decades, but even today we are uncertain of many details. Only a few years ago, MIT astronomer Alar Toomre who has spent years studying spirals wrote: "The old puzzle of the spiral arms of galaxies has continued to taunt theorists. The more they manage to unravel it, the more obstinate seem the remaining dynamics."

One of the first explanations was by T.C. Chamberlin of the University of Wisconsin. In 1900 he proposed that one "nebula" (as they were called then) passed near another, pulling out a long strand of material. At the time, astronomers were still uncertain what these nebulae really were. Several centuries before, German philosopher Immanuel Kant put forward the idea that they were "island universes" of stars — but this was not accepted until the mid-1920s, when Edwin Hubble showed that some of the "nebulae" were in fact made of individual stars.

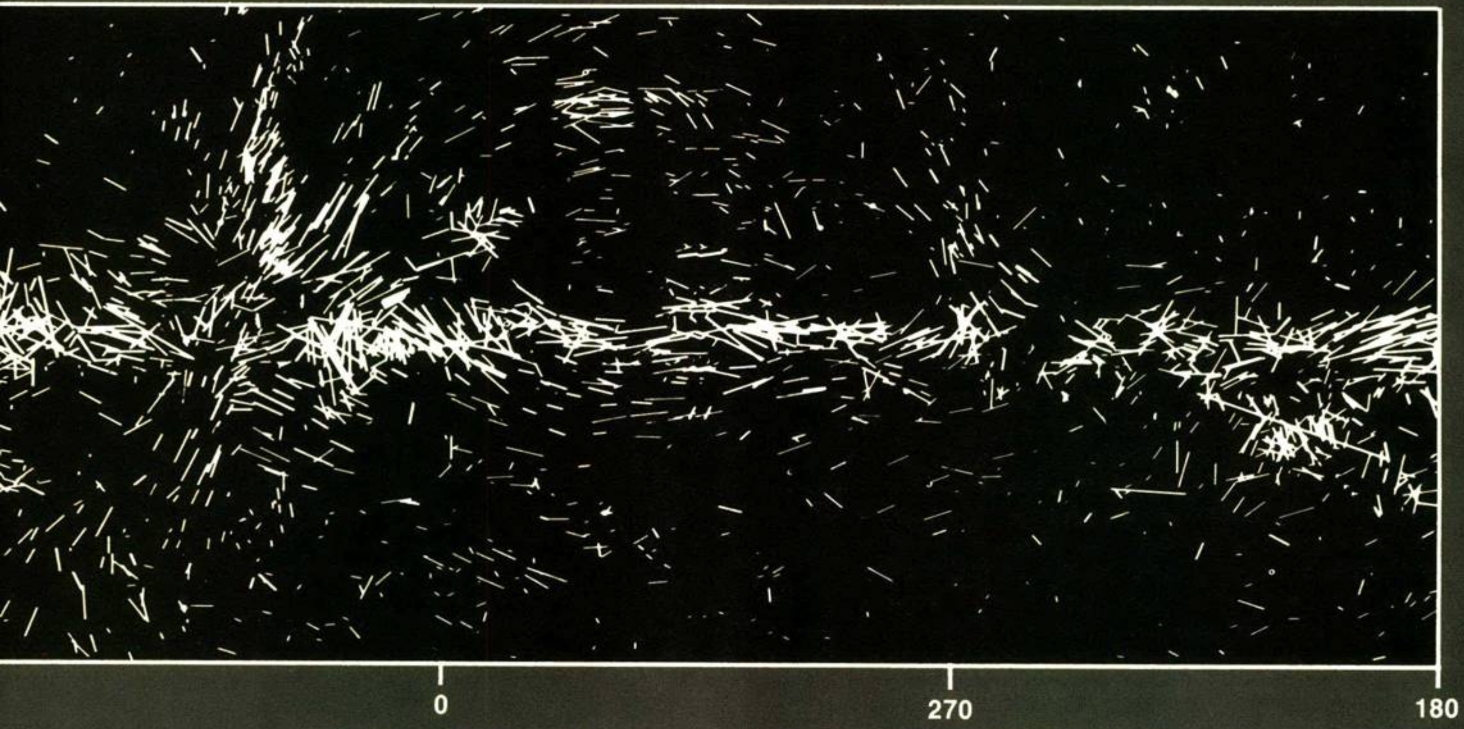
Despite the uncertainty over the nature of galaxies, Vesto Slipher of Lowell Observatory established as early as 1914 that spiral nebula M-104 was rotating about its central axis. Did this mean that all such spirals were rotating? Did our own Galaxy rotate — and if so, how? Early studies indicated a strangely mixed-up motion in the stars around us. Some had particularly high velocities relative to us; others had low velocities. In 1921, Swedish astronomer Bertil Lindblad managed to sort things out. He proposed, after a careful study of the data, that our Galaxy was spinning about a point in the direction of the constellation Sagittarius. The motion of the stars in the neighborhood of the Sun was similar to that of the planets in the solar system. We know, for example, that the closer a planet is to the Sun, the faster it travels. In the same way, stars closer to the galactic core travel faster than our Sun, while those farther out travel slower. Lindblad's differential rotation hypothesis was verified observationally a few years later by Jan Oort of Holland.



Lindblad was basically correct, but we now know the motion of stars within the Milky Way is far more complex than he visualized. Virtually all the mass of the solar system is concentrated in a point at the center (the Sun), but in the case of a galaxy, mass spreads out through the stars. The stellar core of a galaxy rotates like a solid and it is not until you get some distance away from the center that velocities start dropping off as they do in the solar system. In short, *our Galaxy exhibits a form of differential* rotation, but not the simple solar system type.

Nevertheless, it seems we ought to be able to explain spiral arms with this concept. A closer look reveals a

The Galactic Magnetic Field



Interstellar dust responds to the gentle push of the galactic magnetic field by aligning itself with the field. Measurements can then detect the field by the dust's polarizing effect on starlight. Though magnetic fields do not play a dominant role in creating ordinary spiral structure, some evidence shows they may control the development of barred spirals. After D.S. Mathewson, *Memoirs of the R.A.S.*

serious problem, however. Consider our Sun — it lies at a distance of about 30,000 light-years from the center of our Galaxy. Its orbital velocity carries it around the Galaxy once every 250 million years. Since the Sun is almost 5 billion years old, it must have completed approximately 20 orbits. Of course, our Galaxy itself is much older than the Sun — it may have made as many as 60 full turns since it formed.

Let's assume for the moment that differential rotation creates the arms of our Galaxy. In essence, this means they trail because the stars in the outer regions orbit more slowly than those in regions close to the core. Yet something is drastically wrong: after only a few turns, the arms would smear out around the core. And after 60 turns — well, there wouldn't be any arms. They would be smeared so thoroughly that we wouldn't be able to distinguish a spiral galaxy from an elliptical. It's clear that simple differential rotation by itself can't account for spiral arms.

There is another fact to account for: Vera Rubin of the Carnegie Institution of Washington and her group, and a number of other groups, have recently shown that the velocity of the stars in the outer regions of galaxies does not fall off as quickly as expected. As we've seen, in most galaxies the core rotates rigidly. But Rubin's work shows that up to a certain point, the disk containing the spiral arms rotates rigidly, too — though at a slower rate than the core.

If differential rotation isn't the answer, what is? The first clue to a solution came from the work of Bertil Lindblad. Once Hubble had established that some "nebulae" were island universes of stars, Lindblad wholeheartedly attacked the problem of stellar dynamics in such a system. Understanding spiral arms and how they form became his lifelong obsession. He published paper after paper, and although he made a number of important contributions, much of what he did has since been forgotten. Apparently the time was not quite ripe. Many crucial bits of information were unknown to Lindblad and sometimes he chased down blind alleys for years.

A case in point was his obsession with "leading arms." He believed that galaxies rotated with their arms *leading* and that the stars, originally in circular or nearly circular orbits, moved outward as if being shed. According to Lindblad, this was due to the faster rotation speed of the inner stars. He was convinced, in essence, that the arms were unwinding. Most astronomers, on the other hand, were convinced that galaxies rotated with their arms trailing.

Lindblad concentrated on stars; he spent many years calculating individual orbits around a galaxy. He considered the effects of perturbations on the stars and showed that they would be thrown into small, epicycle-like orbits (where a small orbit is superimposed on an overall larger orbit). Then, in the late 1950s, Lindblad discovered that the spiral pattern — the spiral arms — did not rotate as fast as the stars themselves. Compared to the stars, it took twice as long for the spiral pattern to circle around. This led him to the concept of a density wave. He hypothesized that the arms were produced by a wave that moved around the disk independent of the motion of the individual stars.

While Lindblad was doggedly pursuing a purely gravitational explanation, other astronomers explored the idea that spiral arms were due to galactic magnetic fields. The first evidence for a galactic magnetic field came in 1949 when John Hall and W.A. Hiltner of Yerkes Observatory observed that light coming from nearby arms was polarized. Jesse Greenstein and Leverett Davis Jr. of Caltech showed that the polarization was probably due to the alignment of dust particles in a magnetic field. The field lines seemed to run along the spiral arms and, if strong enough, might hold the arms in place. Their strength was believed to be on the order of 20 to 30 microgauss (about $\frac{1}{20\,000}$ the strength of the terrestrial magnetic field) — enough to contain the arms. Eventually, though, they were shown to measure only about 2 to 3 microgauss; at the time, this was thought to be too weak to control the overall structure of a galaxy.

Despite the dead ends, progress was being made that eventually led to a breakthrough. In the late 1940s, Walter Baade and Nicholas Mayall showed that the arms of M-31 stood out mainly because of bright O and B-type stars, and their associated nebulosity. Astronomers soon realized that this applied to most other galaxies as well. The 1950s brought the discovery of 21-centimeter radio emission from neutral hydrogen, and astronomers were able to make the first detailed maps of the arms of our own Galaxy.

Lindblad was certainly on the right track with his density wave idea; his mistake was concentrating on stars. In the 1960s, American astronomers C.C. Lin and F.H. Shu began looking at Lindblad's theory. Like Lindblad, they assumed a density wave swept through a spiral galaxy independent of the motion of its stars. (This wave rotates rigidly: its outer parts make the same number of turns as the inner parts.) But instead of stars, Lin and Shu focused on gas and dust. They figured that if the arms stood out so clearly in part because of their large amount of luminous gas, then gas must play an important role.

Let's see how this mechanism works. Density waves differ from ordinary waves. When you throw a rock into a pond, for example, you get what's called a transverse wave: the molecules of water move up and down perpendicular to the direction the wave travels. The density waves that Lin and Shu visualized were longitudinal waves — like sound waves. When you talk, the vibrations of your vocal cords set up rarefactions and compressions — regions of greater and lesser density — in the air molecules between you and your listener. A density wave also occurs on a busy highway where there has been an accident: cars begin slowing down before the accident scene, bunch close together as they pass it, then speed up and spread out.

As a density wave sweeps around a galaxy, gas and dust are pulled into certain regions and out of others. Since the wave moves slowly, stars and gas clouds catch up to and run into regions of greater or lesser density. In the high-density regions, gravity begins to pull the surrounding gas together. Soon a loose gas cloud breaks up, clumps begin to form, and the clumps collapse to make protostars. From these, full-fledged stars eventually develop — many of them massive, short-lived O and B types. Their lives may be brief, but they are bright and excite the hydrogen gas around them. Seen from a distance, the density wave passes through the galactic disk like a fairy wand, making stars and gas clouds blossom brightly.

A way to join Lin and Shu's gas-cloud theory to Lindblad's stellar one was found by Agris Kalnajs in 1973. He assumed that stars circle the Galaxy in elliptical orbits, just as the planets orbit the Sun. Starting with a model "galaxy" that had only 11 objects in elliptical orbits, he showed that it was relatively easy to get spiral arms. If a star in one orbit is perturbed slightly, the axis of its elliptical orbit begins to precess (slowly change direction). This star affects its neighbor, so its elliptical orbit begins to precess, too. This continues until all 11 orbits are precessing. The results clearly show two spiral arms, and by varying the amount of precession, Kalnajs found it easy to vary the shape and size of the arms.

The Lin-Shu theory had great initial success, but encountered some difficulties because it did not form sufficient numbers of stars fast enough. Then, in 1966, M. Fujimoto pointed out that the density wave was traveling at about 30 kilometers per second, while the gas itself could conduct a wave at only 10 km/sec. This meant the wave was supersonic — it was traveling at approximately three times the speed of sound and had to have a shock front along its leading edge. With this, the puzzle came together. Just as a sonic boom from an airplane tends to shake glassware, walls, and windows, a sonic boom in a galaxy full of dusty gas tends to push clouds together, speeding up star formation. The details came out right, too — according to the theory, most stars should form on the inner (concave) edge of the arms where gas and dust are entering the compression region. Observations bore this out.

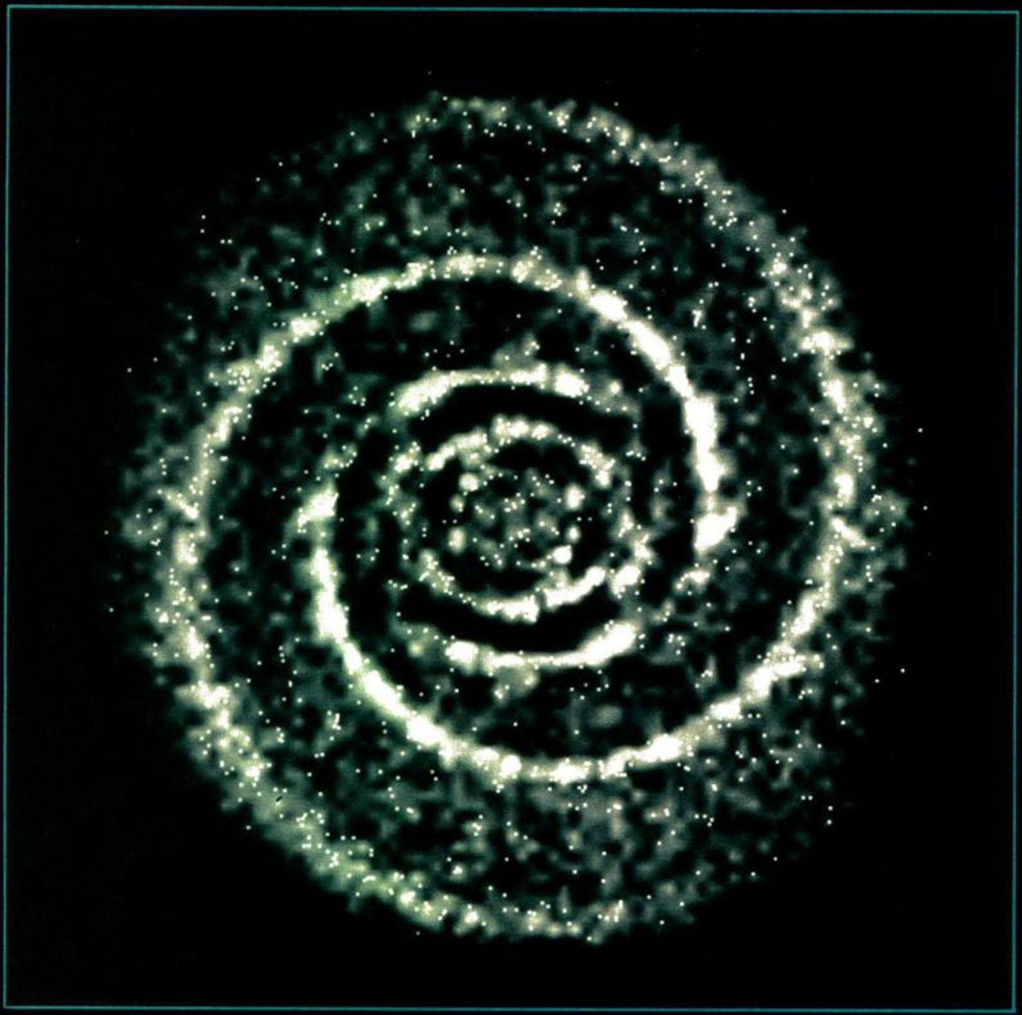
With Fujimoto's addition, it seems we finally have a theory that explains most of what we observe. A density wave moves around a galaxy creating spiral arms. We see the arms because they contain large bright stars and a considerable amount of luminous gas. The stars form because the concentration of gas is higher in these regions and because shock waves compress the gas even further. The large young stars, in turn, excite the gas around them, making it luminous. Case closed — or is it?

If we take a narrower look at the matter, we encounter some inconsistencies. First, although there is little doubt that density waves exist — they've been found in Saturn's ring system, for example — we have no idea what initiates them in galaxies. In short, we can't get the process started on its own. Second, even if we did find out what starts it, Alar Toomre of MIT has shown that although the wave is self-perpetuating and relatively long-lived, it won't last more than about a billion years. Our Galaxy and presumably most others are at least 15 billion years old.

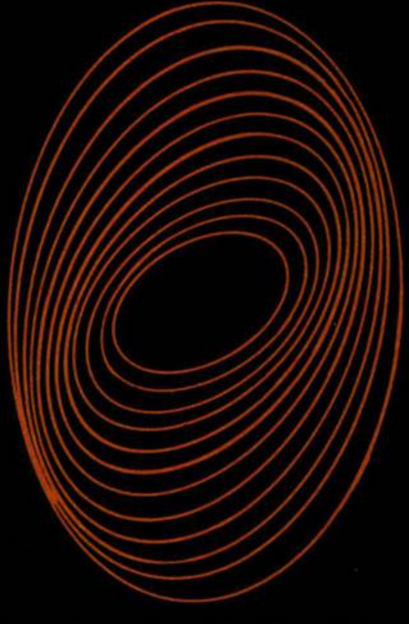
More difficulties loom. In its simplest case the density wave theory creates two arms, although it is possible with shorter wavelengths to generate three. When we look at galaxies, we find that indeed most have two or three arms — but some have more. A good theory should account for this, but ours can't. Worse still is the detailed structure of the arms. Many galaxies have bridges between their arms and spurs that emanate from the sides of the arms. In fact, our Sun lies in one of these spurs — the Orion spur. Can we explain these anomalies using density waves? No.

Even the shock-wave/sonic-boom model has its

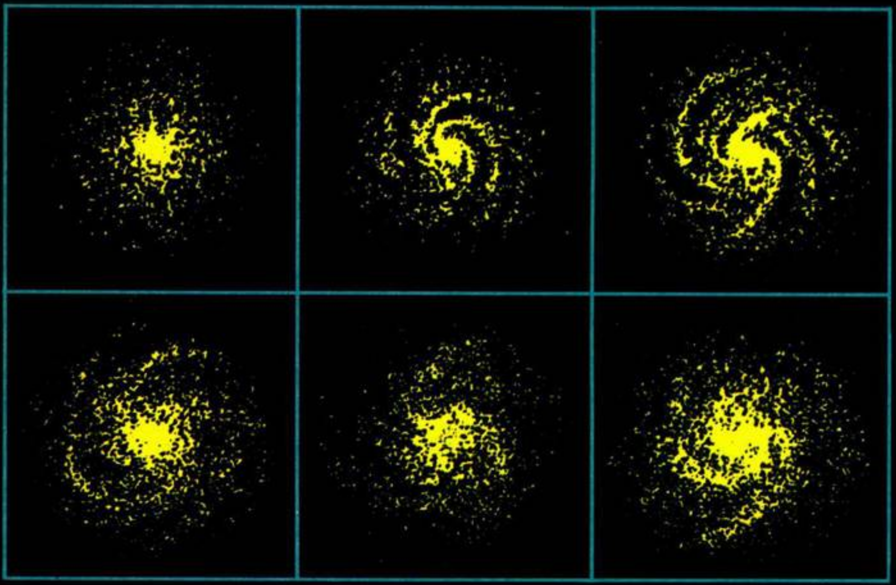
Computer Model Galaxies



With gas clouds (grey patches) and stars (white dots), William Roberts and Mark Hausman developed a model galaxy, seen here at an age of 600 million years. Gas clouds and associations of stars agglomerate into giant complexes in the spiral arms. Photo courtesy W. Roberts.

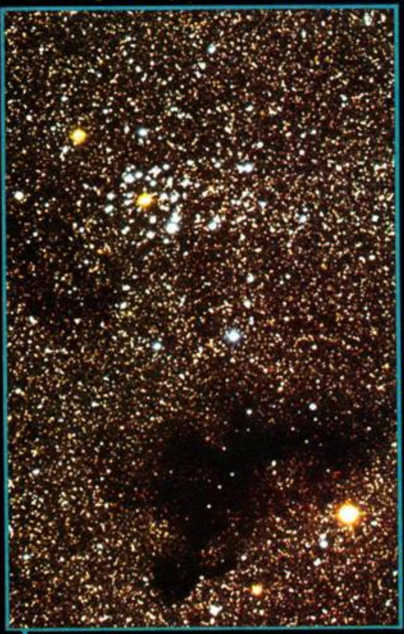


If you set a number of particles orbiting a galaxy in elliptical paths, their mutual perturbations will precess the orbits and yield "spiral structure." Diagram after the work of Agris Kalnajs.



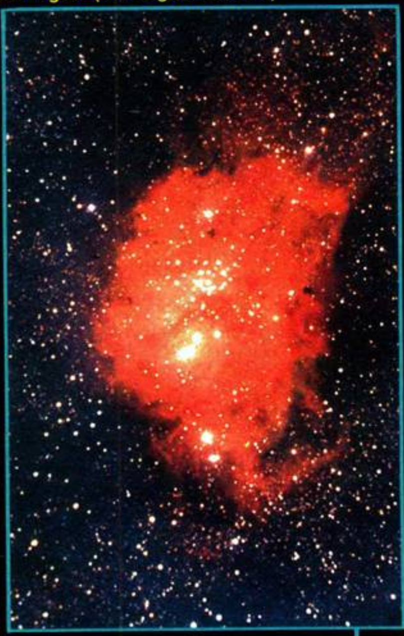
If spiral arms can last only about a billion years, how can a 15 billion year old galaxy display them today? J.A. Sellwood and R.G. Carlberg used star formation to cool the disk of their model galaxy — and found that spiral structure will form, break up, and re-form endlessly. Diagram courtesy of R. G. Carlberg.

Spiral Arm Cross-Section



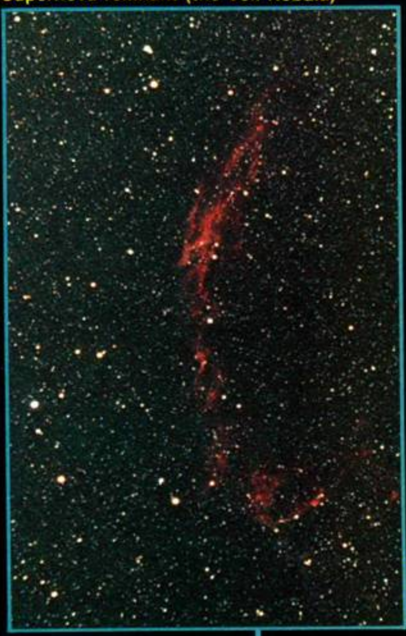
Dark dust globule (Barnard 86)

Anglo-Australian Telescope Board



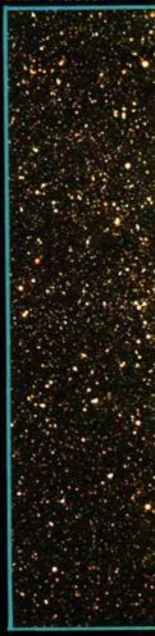
HII region (the Lagoon Nebula)

Orien Ernest

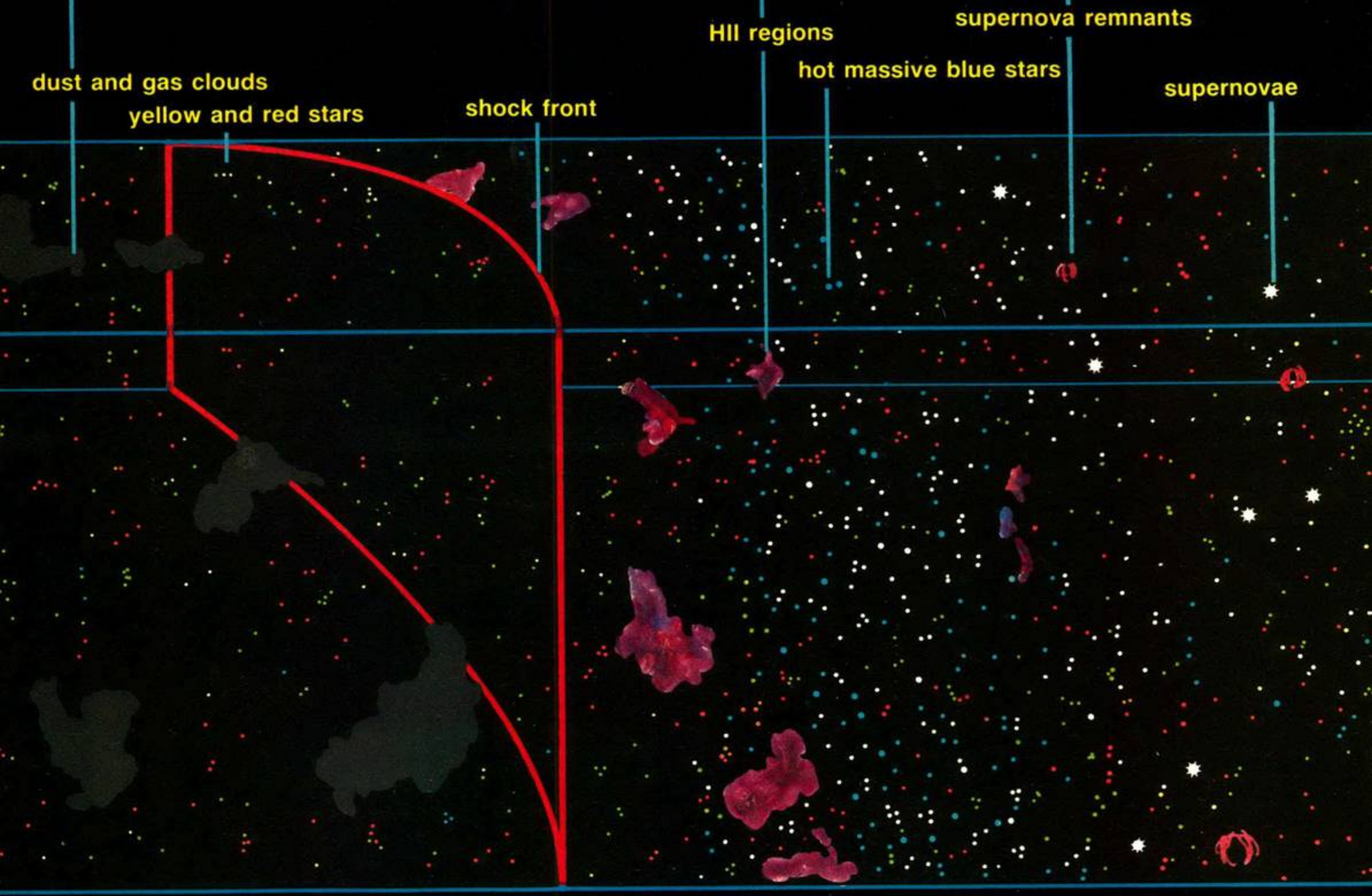


Supernova remnant (the Veil Nebula)

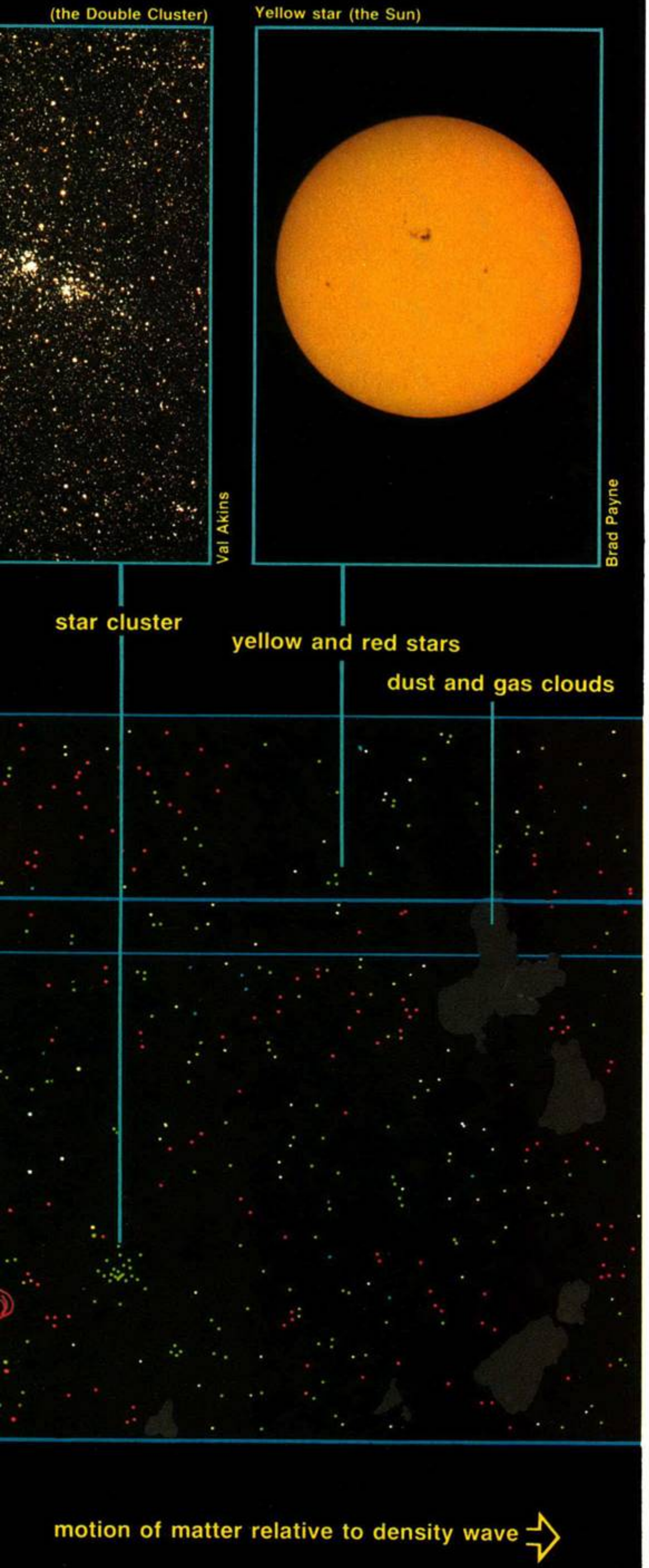
Jim Riffle



Star cluster


HII regions
supernova remnants
dust and gas clouds
hot massive blue stars
yellow and red stars
shock front
supernovae

Density waves rotate at half the speed of galactic material — therefore stars, dust, and gas clouds overtake and pass through this region from behind. After passing the shock front (red line), gas clouds begin to collapse, forming HII regions, stars, clusters, and associations. Soon, the most massive stars become supernovae and enrich the interstellar medium with their debris. After a while, all that is left are dusty gas clouds and the small, cool, yellow and red stars. When this conglomeration hits the next density wave, the process begins anew.



difficulties. Some galaxies have narrow arms while others have broad ones. We ought to be able to explain this via the shock-wave theory, but again we can't. Another problem: galaxies appear to have gigantic halos that extend well beyond the limit of visible stars. How do these affect the arms? Other than helping the arms rotate faster than normal, we don't know.

Our neat and tidy picture is suddenly in tatters. Whatever happens in the majority of spirals, it's clear that none of our present models will explain all the variety we see. Well-established star formation theory says that when a large gas cloud breaks up, stars frequently form in clusters with massive, supernova-prone members. There are several such clouds in a typical galaxy. The expanding gas from one cloud, driven perhaps by supernova shock waves, could compress its neighbor clouds and speed star formation in them. Some of these stars will also explode as supernovae and affect their neighbors in the same way. For example, if a string of clouds — lit by bright stars, gas, and chain reactions of supernovae — extended outward from the galactic core, its inner section would soon shear in the direction of the galaxy's rotation, giving the string a spiral form. And since the bright stars that define the arm at any given moment are short lived, the arm fades from view long before differential rotation can wind it up tightly. Many astronomers believe that the arms in some spirals — especially ragged, irregular ones — may have formed this way.

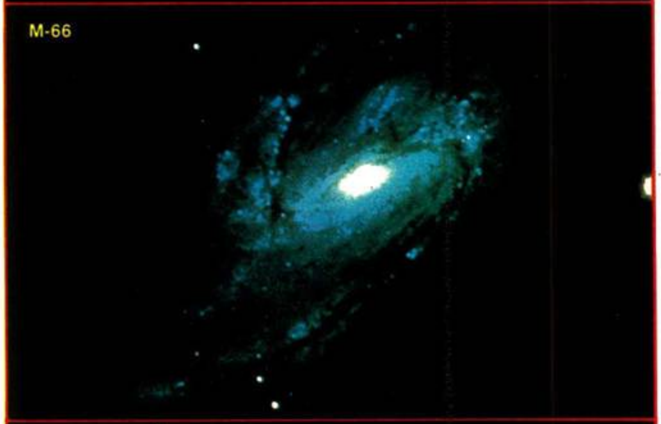
Halton Arp of Mt. Wilson and Las Campanas Observatories has suggested another possibility. His idea stems from one presented in the 1940s by Russian astronomer Viktor Ambartsumian who hypothesized that matter was being thrown out of the cores of galaxies. Radio astronomers have long noticed that some galaxies expel clouds of gas in opposite directions. Arp suggests that arms may result from such an ejection. According to his theory, gas clouds are thrown out in opposite directions. Bright supergiant stars then form from this gas and differential rotation pulls them into a spiral. Arp avoids the problem of tight winding by noting that bright stars are short lived. He points to many anomalies in galaxies which he believes can be best explained by his theory, such as knots in the arms and small galactic companions at the ends of some arms.

There is yet an additional way to make spiral arms, and it seems likely that at least a few actually are created in this fashion. If one galaxy nearly collides with another, gravitational attraction between them will pull out a long strand of material. Such collisions have been computer simulated and the results look quite similar to a number of observed objects.

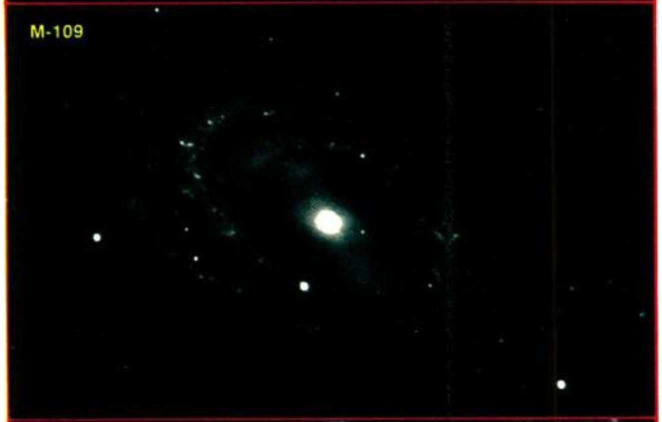
Much of today's theoretical work on the spiral structure of galaxies is done on large computers. Most studies use the N-particle method, in which the stars of a galaxy are represented by points that attract one another gravitationally. The distribution of these points as the galaxy evolves can be followed over billions of years. Unfortunately, a typical galaxy consists of about 100 billion stars and there is no way for present computers to keep track of so many points. Theorists have been forced into developing their models using "watered-down" galaxies — hopefully without distorting the results too badly.

One problem being looked at with computers is the lifetime of density waves. According to Toomre, they can't last longer than about a billion years. Why, then, do they

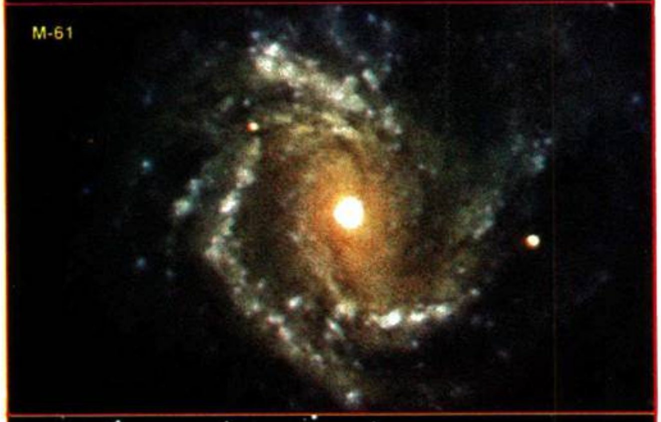
Density wave theories can explain a lot, but they don't fit everything. Why does M-66 look folded? M-109 has beautiful and almost classic spiral arms — but what makes its nucleus look so strange? Why does one of M-61's arms bend abruptly? And what happened to NGC-2442? Each is a question far easier to pose than to answer — but until good answers for these and other oddball cases are forthcoming, the density wave model is only a partial success.


M-66

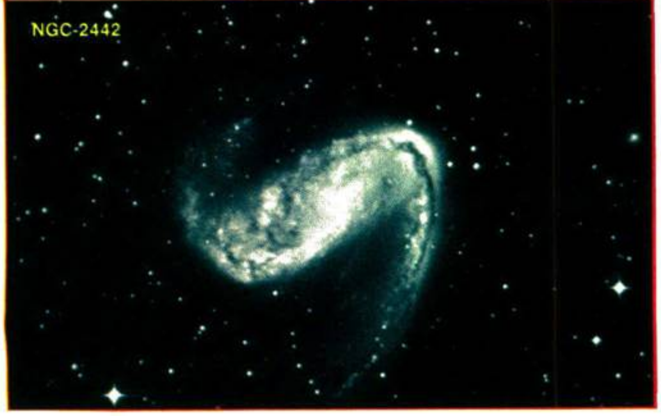
U.S. Naval Observatory


M-109

Lick Observatory


M-61

James D. Wray


NGC-2442

Royal Observatory Edinburgh

appear much older? J.A. Sellwood of the Institute of Astronomy, Cambridge, and R.G. Carlberg of the University of Toronto started with a simulated galaxy of 20,000 particles and examined the effects of cooling on its disk. They cooled their galaxy by dissipating gas and forming stars. They found that cooling prevents the disk from stabilizing completely and as a result the spiral structure is an endlessly-recurring phenomenon. It appears sometime after the birth of a galaxy, then it disappears, only to reappear again later, and so on.

In another recent study, Mark Hausman and William Roberts at the University of Virginia approached the problem of spiral structure differently. They noted that most N-particle studies took the "particles" to be stars. But since structure is largely associated with gas, their galaxy was composed of 2,500 to 10,000 "cloud particles." Each orbited in the galaxy's gravitational field, but was allowed to collide with others. Hausman and Roberts also allowed for supernova explosions within the galaxy.

It turned out that a galaxy is affected more by the galactic gravitational field than by the details of star formation. Yet Hausman and Roberts verified that sharp, well-defined spiral arms can occur only if the time between the birth and death of stars is fairly short. In effect, spiral arms come only from massive, bright, short-lived objects.

So far, so good — but an important factor is missed when computer studies treat galaxies as simple collections of gas and stars. The gaseous material in a galaxy is actually a plasma — a mixture of positively and negatively-charged particles (usually electrons and protons) that is electrically neutral overall. Plasma is affected by any electrical or magnetic fields, and we know that galaxies have weak magnetic fields.

A number of groups, including one headed by Anthony Peratt of Los Alamos National Laboratory, rolled the effect of a magnetic field into their models. Until recently, it was impossible to do this because of the large number of calculations required. However, the development of exceptionally-fast supercomputers with tremendous storage capacities now allows theoreticians to simulate galactic disks of 300,000 particles and more.

Peratt and his group studied the formation of bars in barred spirals and found their shape and size depends quite strongly on the galactic magnetic field. The researchers have also shown that when two galactic-sized clouds of plasma collide, their magnetic fields can interact to form a spiral galaxy.

Where do we stand then? Is there any theory that wraps up all the spiral galaxies in a single package? Unfortunately, there isn't — though suitably modified, the density wave theory has a great many successes to its credit. Astronomers have learned a tremendous amount about galactic structure in the past few years. Computers have been extremely helpful and will become even more important in the future, but there is still much to be learned and much to be done. It's a fertile field awaiting clever new ideas — and the ingenious somebody who will tie the loose ends together and give us a comprehensive and complete theory.

Barry Parker teaches physics at Idaho State University and is author of the textbook, Concepts of the Cosmos. *His last article for ASTRONOMY was "The Mystery of the Missing Mass" featured in the November 1984 issue.*

There are a lot of places you can buy a telescope.

Orion is the best. Here's why.

Low Prices

Orion's prices are among the lowest you'll find anywhere. Save hundreds of dollars on all the popular brands of telescopes. Big savings on accessories, too. And with our money-back guarantee on every purchase, you can't lose.

Huge Selection

We carry over 1,400 items — astronomical & terrestrial telescopes, binoculars, eyepieces, camera adapters, books & star atlases, electronic control systems, and many unique products you'll really like.

CELESTRON
PRECISION OPTICS

Edmund Scientific

Meade

BUSHNELL

AccuTrack™

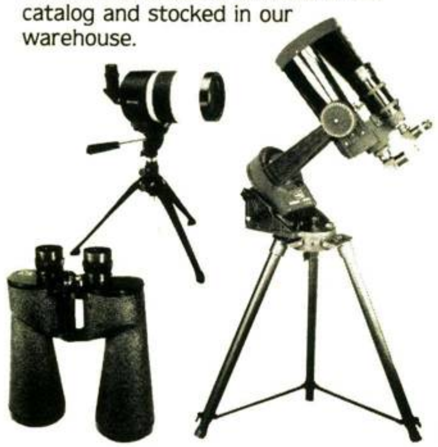
SWIFT

BAUSCH & LOMB

TeleVue

Major Brands

Celestron International. Meade Instruments. Bausch & Lomb. Edmund Scientific. TeleVue. Bushnell. Swift Instruments. Every major brand of telescopes and accessories available is listed in our catalog and stocked in our warehouse.



Free Catalog

Our giant catalog is filled with all the major brands of telescopes, complete accessory listings, and lots of helpful information to make your selection easier. Complete price list, of course. Why not call or write for your copy today?

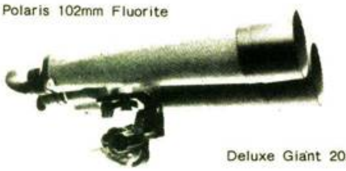
NEW CELESTRON SCOPES NOW AT ORION!

Super Polaris C-8

Polaris 8"f/5 Newtonian

Polaris 102mm Fluorite

Sky Sensor
Computer Control



Deluxe Giant 20x80's

Honest Advice

We want to save you money, so we're happy to tell you what NOT to buy, if we feel a product you want is not right for your needs. We promise to never recommend a product just to make a sale. And if we don't have what you want, we'll suggest another company where you can find it. Let the telescope experts at Orion help you with all your telescope questions.

Toll Free!

800-447-1001
IN CALIF. 800-443-1001

Serving amateur astronomers worldwide since 1975.

ORION
TELESCOPE CENTER
A division of Optronic Technologies, Inc.
P.O. Box 1158-A
Santa Cruz, CA 95061

ASTRONOMY
Forum

Selling Comet Halley

It's been nearly 76 years since our solar system's most famous snowball made its last appearance. Some people still remember its filmy tail sweeping across the night sky.

But times were different in 1910. Even city skies were fairly dark back then but most people lived in the country, where the skies were pitch black and the Milky Way sparkled every clear night. Telescopes were few and far between and too expensive for most people.

In 1910, there was no television or radio. Only newspapers and illustrated news magazines spread the word of Comet Halley's approach to a credulous public. When Earth passed through Halley's tail, the papers sensationalized the fact: "Earth to be bathed in deadly cyanogen gas!" Unscrupulous businessmen preyed on the ignorant public, offering gas masks and "comet pills" to protect against the end of the world.

In 1948, when Comet Halley reached its maximum distance from the Sun, hardly anyone contemplated an event still 38 years in the future — they had other things to worry about and a world to rebuild.

But even then, events for Halley's next homecoming were under way. The optical industry, which had grown dramatically during two World Wars, turned its efforts to the civilian consumer market. During the 1950s, more and more domestic manufacturers came "on line" as small but rapidly-growing companies. Some businessmen sold imported optics, often from Japan, and their efforts helped fuel America's interest in space and astronomy. Popular scientific magazines flourished. And a new phenomenon sprung into being: the mass marketing of astronomical telescopes. Many of the telescopes advertised were "junk," but even these served those curious about the night sky. As the American space program reached full speed in the early 1960s, amateur astronomy was a growing hobby — and the fledgling astronomy industry was reaping the benefits.

However, still only a small percentage of the populace owned a telescope or binoculars. The space program had helped to generate public interest in looking up, but what the industry really needed was a catalyst to sell astronomical instruments — something that would captivate the world's interest. Something spectacular and mysterious. Moreover, something so special it couldn't be missed at any cost.

No, it wasn't to be Halley — that was still a decade away. Without warning, Comet Kohoutek burst on the scene. Discovered while it was still distant from the Sun, Kohoutek got good press coverage — and lots of it. Hailed as the "Comet of the Century," it embarrassed both astronomers and telescope manufacturers: the astronomers because they had been wrong; the manufacturers because they weren't ready for it. Orders for telescopes poured in like never before. Telescope manufacturers couldn't make them fast enough! The hoopla generated by Kohoutek helped fire my interest in astronomy. Unfortunately, I never did see the comet no matter how hard I looked with my shiny new 60mm refractor. I felt bitterly disappointed. But when it was all over, the marketers had discovered a wonderful equation:

Comet × Halley = $$$.

Comet Halley couldn't get here soon enough!

No better event could have been conceived by the minds of men for the purpose of selling astronomy to the masses. Walk up to anyone on the street, ask them to name a famous celestial object, and they'll probably mention Halley's Comet. Seeing this comet of comets is a once-in-a-lifetime event — its period just a little longer than the Biblical threescore and ten — definitely something not to be missed.

Few celestial objects are as spectacular as a comet, with its long sweeping tail and brilliant head. Despite the fact that most comets are small and faint, they're exciting nonetheless. A comet can be seen from nearly everywhere on the planet and in the case of Halley, it will be visible for many months. Most important of all, Comet Halley's predicted return is a long-established fact, which gives marketers time to promote the product.

There have been many moves to maximize profit on Halley's return. A California firm which makes and sells quality telescopes is not the first, nor will it be the last, to label standard refractors, reflectors, and binoculars with "Comet-" as part of the name.

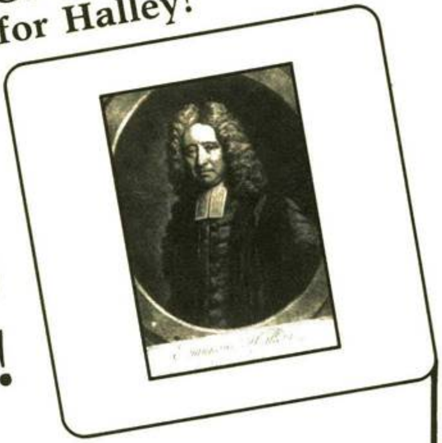
Consider a Florida-based sales organization, long known for its inexpensive refractors and reflectors, which has recently introduced a wide range of small telescopes known as the "Halley's Comet Series."

There's another company, this one Kansas-based, quite actively marketing "Comet Chaser" telescopes — a line of small catadioptric Newtonians on alt-azimuth mounts.

The most recent entry to the fray is the Halleyscope, which has been touted in the print media. It's a 40mm spotting scope with a zoom range of 8 to 32 power, and includes a camera adapter to photograph its namesake.

A few days ago, I happened to be watching *Wall Street Week* on PBS. At the end of the program, a panel of investment experts fielded questions that viewers had written in. I almost fell off my chair when I heard,

Get Ready for Halley!



New!

Comets and Comet Halley

a slide set by John C. Brandt

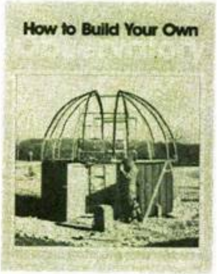
Are your non-astronomer friends driving you crazy with questions about "Hailey's" Comet? Do you ever wish for a set of comet slides you could haul out and show them? Or — would you like a personal pictorial souvenir of its historic return? Dr. John Brandt, noted NASA comet astronomer, has chosen 31 key slides that depict Halley's Comet and describe and illustrate the space probe missions headed for it. A 15-page informative booklet by Brandt accompanies the set. Be ready for Halley!

31 slides (17 in color), boxed with booklet. **$22.95**

To order, use the AstroMedia order form bound into this issue, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

HOW TO BUILD YOUR OWN OBSERVATORY

reprints from TELESCOPE MAKING

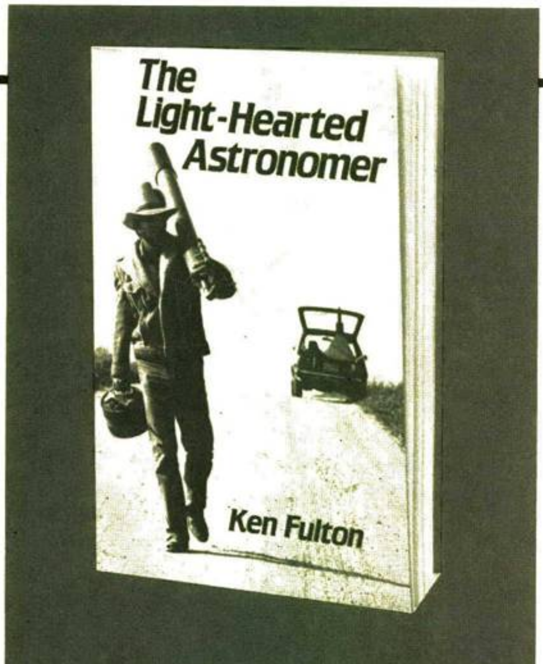


To enjoy the hobby of astronomy to its fullest, you really need an observatory. Our booklet contains complete plans for 10 backyard observatories — everything from a simple shelter from streetlights to a gleaming garage-top dome. Each plan includes clearly written, easy-to-follow instructions, diagrams, and plenty of photos.

42 pages, paperback, $3.95

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Corp., Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

FROM THE PUBLISHER OF ASTRONOMY.



"I made a big mistake when I purchased my first telescope. How I wish Fulton would have written this book sooner!"

— *Galileo*

"Fulton has done astronomy an invaluable service. I think a lunar crater should be named after him."

— *Plato*

The Light-Hearted Astronomer

A Survival Manual for Amateur Astronomers

Written by Ken Fulton, a frequent contributor to ASTRONOMY, **The Light-Hearted Astronomer** includes chapters such as: Amateur Astronomers — A Strange Breed; The Ads; The Telescopes; What Accessories Do You Really Need?; Seeing What You Observe, Observing What You See; Living With a Non-Astronomer Spouse; Is the Universe a Harsh Mistress? In his distinctive and humorous style, Fulton tackles these topics and many more. This new book offers something never yet published: a "survival manual" for amateur astronomers that tells it like it *really* is!

128 pages, paperback, 5½" x 8½"

The Light-Hearted Astronomer $6.95

To order, use the AstroMedia order form bound into this magazine or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

"Considering the upcoming apparition of Halley's Comet, in what ways can I invest to maximize my profit?" In case you're interested, the panel suggested buying stock in Bausch & Lomb, Kodak and Commodore Computers. The first two suggestions are pretty obvious, but the Commodore tip was based on software being developed by Commodore pertaining to the comet.

Halley is helping to promote much more than telescopes. Books, T-shirts, bumper stickers, motion pictures, ocean cruises and tours to southern lands are but a few of the things borrowing from its fame. As the comet draws closer, maybe we'll find Comet Halley breakfast cereal next to boxes of Mr. T on supermarket shelves. And perhaps we'll see the comet get its own Saturday morning cartoon show! Keep your eyes peeled for gas masks and comet pills, and the tabloid headlines predicting that Halley will destroy Earth. It's all good capitalist fun, really . . . .

If we examine the techniques used to sell Halley, we see a classic case of "selling the sizzle." The upcoming apparition of Comet Halley will be quite unfavorable, especially for observers in the northern hemisphere. Most advertisements show the comet as a brilliant spectacle, which it almost certainly will not be.

No doubt some good will come of it, though. A lot of interest in astronomy will be generated by the media blitz — and some of the new enthusiasts may continue in the hobby thanks to the catalyst Comet Halley will provide. But many spectators will be disappointed: trying to see the comet with inadequate telescopes under light-polluted skies, with grandiose expectations of how it should look to their untrained eyes.

But I worry and wonder about the harm that could result from exploiting Comet Halley. As it once again wheels out of the inner solar system, how many millions of people will consign their "Comet" and "Halley" telescopes to closets and attics, thinking they've been ripped off by "the astronomers" again?

Clive Gibbons
Burlington, Ontario

— AstroMedia is, of course, exploiting the return of Halley's Comet as eagerly as everyone else. But we hope that the positive effects of introducing a lot of people to astronomy by means of the comet will offset the commercialization necessary to sell a "product" in today's marketplace.

EPP-sih-lon AWE-rih-gai

EPP-sih-lon Awe-REE-gai
EPP-sih-lon Awe-REE-jay
EPP-sih-lon Awe-REE-jee
EPP-sih-lon Awe-RYE-jee
EPP-sih-lon Awe-RYE-gee
EPP-sih-lon AWE-rih-gai
EPP-sih-lon Oh-RIDGE-eye

No matter how you say it, this is one very peculiar star.

Actually, it's not just a single star, but a binary pair — and at least one group of astronomers thinks it's triple.

Epsilon Aurigae is the northernmost of the three naked-eye stars that make up "the Kids" in the constellation of Auriga, the Charioteer. It spends most of its time at third magnitude, but once every 9,885 days — 27.1 years — it drops in brightness by 0.8 magnitude, stays that way for about 11 months, and then returns to normal brightness, reaching it again some 700 days after it first began to dim.

Discovered over 150 years ago, Epsilon's variability is the result of a dark companion object whose orbital motion carries it in front of the brighter star, partially eclipsing its light. Algol (Beta Persei) is the prototype for such systems, called eclipsing binaries. The stars that make up Algol are pretty well understood, but the exact nature of Epsilon Aurigae's companion object has vexed astronomers right from the start (see "Mystery Star," ASTRONOMY, August 1983).

In January 1985, about 50 astronomers convened in Tucson, Arizona for a two-day workshop led by NASA astronomer Robert Stencel on Epsilon Aurigae's most recent eclipse, which ended in late spring 1984. The purpose of the meeting was to discuss and summarize observations, hammer out a consensus on the meaning of the data, and, if possible, construct a model for the secondary object.

The recent eclipse had been the target of a large and concerted effort by both professional and amateur astronomers worldwide. While the professionals studied the star with sophisticated instruments and very large telescopes, a network of amateurs set about establishing a fundamental base line: the light curve — a plot of how the star's brightness changed throughout the entire eclipse.

To start off the workshop, veteran photometric astronomer Frank Bradshaw Wood of the University of Florida summed up the observational history of the system. After describing its many intricacies and oddities, Wood finished by declaring that "nowhere but here has the contribution of the amateur been higher."

A brief discussion followed, then Jeffrey Hopkins, a Phoenix amateur who had coordinated the photometric observations and whose backyard telescope had contributed much to the eclipse monitoring program, stood up and with about two dozen slides pointed out the main features of interest in the eclipse. (The entire visual light curve, held up for view by fellow amateurs Russell Genet and Lewis Boyd, was a sheet of chart recorder paper over 10 feet long!) The light curve generated lots of comments because it showed that the star grew brighter at mid-eclipse: the flat bottom of the eclipse light curve had a distinct bump at its midpoint. This feature appeared in the 1955-56 eclipse, also.

The next speaker was Dana Backman, a young astronomer at the University of Hawaii. He and several co-workers had studied Epsilon at infrared wavelengths from 1 to 60 microns with ground-based telescopes and with IRAS. His results point to the secondary object being a disk about 10 astronomical units across and 1 AU deep that contains baseball-sized objects. The disk has a temperature of about 500 Kelvins, and Backman's work leads him to believe it has a double star system at its center (see AstroNews, January 1985).

Jim Kemp of the University of Oregon then spoke about his optical polarization measurements. After reviewing the observations, he presented a model for the entire system. Projected on the screen, it brought a small gasp of surprise or delight from the audience. Kemp believes the main star — a type F supergiant with a temperature of about 7600 K — has a tenuous disk of material around it, tilted about 45° to the secondary star's orbit and pulsating in and out every 100 days or so.

The disk that surrounds the secondary object is also tipped to its orbit, but very shallowly — about 5°. At maximum, the secondary object covers about half the primary star. We are looking at the system almost in the plane of the secondary object's orbit, being only some 3° away from it. Said Bob Stencel, "I suspect you may win the award for the most intricate model." Kemp closed by saying that observations he plans to make outside of the eclipse should pin down a lot of "ifs" and "maybes" in his model.

Much of the ensuing discussion centered on how far away the system was, since many important details hinge on the objects' physical size. But the distance observations are maddeningly imprecise: the standard distance in the literature gives 600 parsecs but, as one of the workshop participants worked out later, anything up to 2200 parsecs would not conflict with what's been observed!

CELESTRON® CLOSE*UP NEWS NOTES

C14 on Kitt Peak

A Celestron C14 is now a part of the public program at Kitt Peak Observatory in Tucson, Arizona, the nation's largest observatory. It is currently being used at night for the 100,000+ visitors per year and will soon be equipped with an H Alpha filter for solar viewing.

New C90!

A limited production C90 Designer Brass Astro Telescope is now available featuring a new Brass Ultra-High-Tech finish. Same quality optics as the C90 Astro. Also includes, 18mm and 30mm Kellner Oculars, .96" Star Diagonal, 5 x 24 Finderscope, Drive Cord, Electric Clock Drive, Fork Mount with Slow-Motion Controls, Setting Circles, Tripod Adapter Block, Case and Lens Caps.

Open Forum

We're interested in your ideas and needs toward the possible development of a 20 inch Schmidt-Cassegrain. Send all ideas and opinions to the attention of Mr. Kevin Ritschel.

New Free Color Brochures

Send for the new full color Celestron brochures on Celestron Telescopes, Cometron Telescopes, Spotting Scopes and Binoculars. Address listed below.

Celestron Day Prize Winners

Mrs. Lee R. Pepping of Seabrook, Texas was announced as winner of Celestron Day First Prize, a Super Polaris C8 with Sky Sensor. Two Firstscope 80's were awarded to Roy E. Lett, Jr. of Tallahassee, Florida and Karen Schmitt of Springfield, Missouri.

Celestron to exhibit at Riverside Telescope Maker's Conference

Visit the Celestron booth at the Riverside, California Astronomy Show, Memorial Day weekend, May 25-26. We'll showcase the Super Polaris series of telescopes with Sky Sensor, Fluorite telescopes and Schmidt-Cassegrains as well as binoculars and spotting scopes. The Celestron C14 will be on display for viewing. See you there!

Coming of Age

Celestron, manufacturer of the world's most popular telescope, begins its 21st year. Since 1964, Celestron has produced large diameter telescopes beginning with the 20 inch Schmidt-Cassegrain observatory research telescope--the predecessor of the C8.

CELESTRON®
PRECISION OPTICS
P. O. Box 3578-B5B, 2835 Columbia St., Torrance, CA 90503 (213) 328-9560

CALL FREE 1-800-421-1526

Thomas Ake, a guest observer on the International Ultraviolet Explorer satellite, spoke next on the UV eclipse. How deep the eclipse went, and whether you saw one at all, depended strongly on what wavelength you observed at. Progressing from visual wavelengths deeper into the UV meant that the eclipse deepened also — up to a point. Shortward of about 1500 Angstroms the eclipse shallowed and by 1250 A it was virtually nonexistent. At these wavelengths the primary star "turns off" and we see just the UV flux from the secondary.

Steno Ferluga of the Trieste Astronomical Observatory, the next speaker, had observed Epsilon with high-resolution spectroscopy before, during, and after the eclipse. His report confirmed that the primary star was an F0-type supergiant star and the secondary was a cool body. He also showed evidence for a thin shell of gas surrounding the secondary.

After a discussion of Ferluga's talk, the workshop adjourned for the day, although many participants took advantage of an advertised "free Margarita social hour" in one of the conference hotels. In a cavern-like basement lounge, amidst corn chips, popcorn, and not a few weak Margaritas, much more discussion ensued. For lack of the traditional material to write on (". . . this calculation is strictly back-of-the-envelope, you understand . . ."), the cocktail napkins got a heavy workout as participants rehashed the day's talks and critiqued models for the system.

"I don't think we'll ever know what this thing is," sighed one astronomer.

The next day's sessions began with a survey by Ronald Webbink of the University of Illinois, which explored how systems like Epsilon Aurigae might evolve. The possibilities ran a broad gamut — from Epsilon being a newly-formed binary to it being an old and well-evolved system that has ceased transferring material from the larger F star to the secondary's disk. The discussions favored the latter model.

Then Douglas Hall of Vanderbilt University spoke about the IAPPP — the International Amateur Professional Photoelectric Photometry association — and how it organized and coordinated the photometric results from amateurs and professionals of Epsilon's eclipse. "Here's a list of all the amateur observatories that contributed useful data," he said. "The apertures range from 4 inches to 24 inches. And don't laugh at the 4-inch telescope — that photometry happens to be very, very good!"

Amateurs, Hall said, have discovered many new variable stars. Referring to one professional astronomer's object of interest: "There's your baby, HR 1099 — that was discovered by an amateur with an 8-inch telescope in downtown Atlanta." A ripple of laughter ran through the room. Then, returning to Epsilon Aurigae, Hall echoed Brad Wood's opening comment, "Epsilon Aurigae is an excellent example of just the sort of thing that amateur photometry can do. In the photometry of this eclipse it is almost entirely an amateur effort — if it hadn't been for them, there wouldn't be any light curve."

After Hall's talk, several papers filled in details on the eclipse — Ed Guinan described his narrow-band photometry and Kenneth Hinkle his observations of carbon monoxide, to mention two of them. Guinan's model showed jets of hydrogen gas squirting out at the poles of the disk and a small notch in the disk itself. The jet would account for the enhanced hydrogen absorption seen at mid-eclipse and the notch would let light from the primary through — this could explain the mid-eclipse brightening.

The photometry of Epsilon Aurigae's eclipse is almost entirely an amateur effort — if it hadn't been for them, there would be no light curve.

The workshop concluded with two talks. The first was by Jeff Hopkins, who described how he took a standard 8-inch Schmidt-Cassegrain telescope and designed and built his own photometer for it (the available commercial ones were far too large and heavy). He uses a Commodore 64 personal computer (". . . very attractive price!") for data acquisition and reduction. Besides working on Epsilon, Hopkins has also been observing RS Canum Venaticorum binary variables and is doing high-speed photometry of lunar occultations of spectroscopic binaries such as Eta Leonis. A new project — an outgrowth of the Epsilon Aurigae eclipse — focuses on other long-period eclipsing binaries like 31 Cygni, 22 Vulpeculae, and Tau Persei.

The last talk was given by Russell Genet of the Fairborn Observatory. He described the observations of Epsilon Aurigae, made with the Automated Photoelectric Telescope (APT) at the home observatory of Lewis Boyd, another resident of Phoenix, and future plans for monitoring the star. (Boyd was present, but on crutches after a fall from a ladder.) Boyd's telescope is an equatorially-mounted 10-inch Newtonian with computer-controlled drives on both the r.a. and dec. axes. The computer runs the telescope automatically: it finds the target star, makes the measurements, offsets to get sky, comparison, and check star readings, then repeats the process on another star. Boyd's APT can do excellent photometry on 80 stars a night — far more than a manual observer could.

In the hotel lobby after the workshop adjourned, Russ Genet and Lou Boyd outlined an intriguing idea they have that mixes amateur astronomy with the professional kind. The basic idea is for a "telescope farm" — a site where about a dozen APTs would scan the skies nightly under computer control. The APTs would gather reams of brightness data for any astronomer — amateur or professional — who needs lots of photometry on lots of stars.

The "farm" is still only a plan, but already a site about an hour south of Tucson has been chosen which will soon have four APTs set up and running. The site will eventually have several telescopes in the 16 to 30-inch size range.

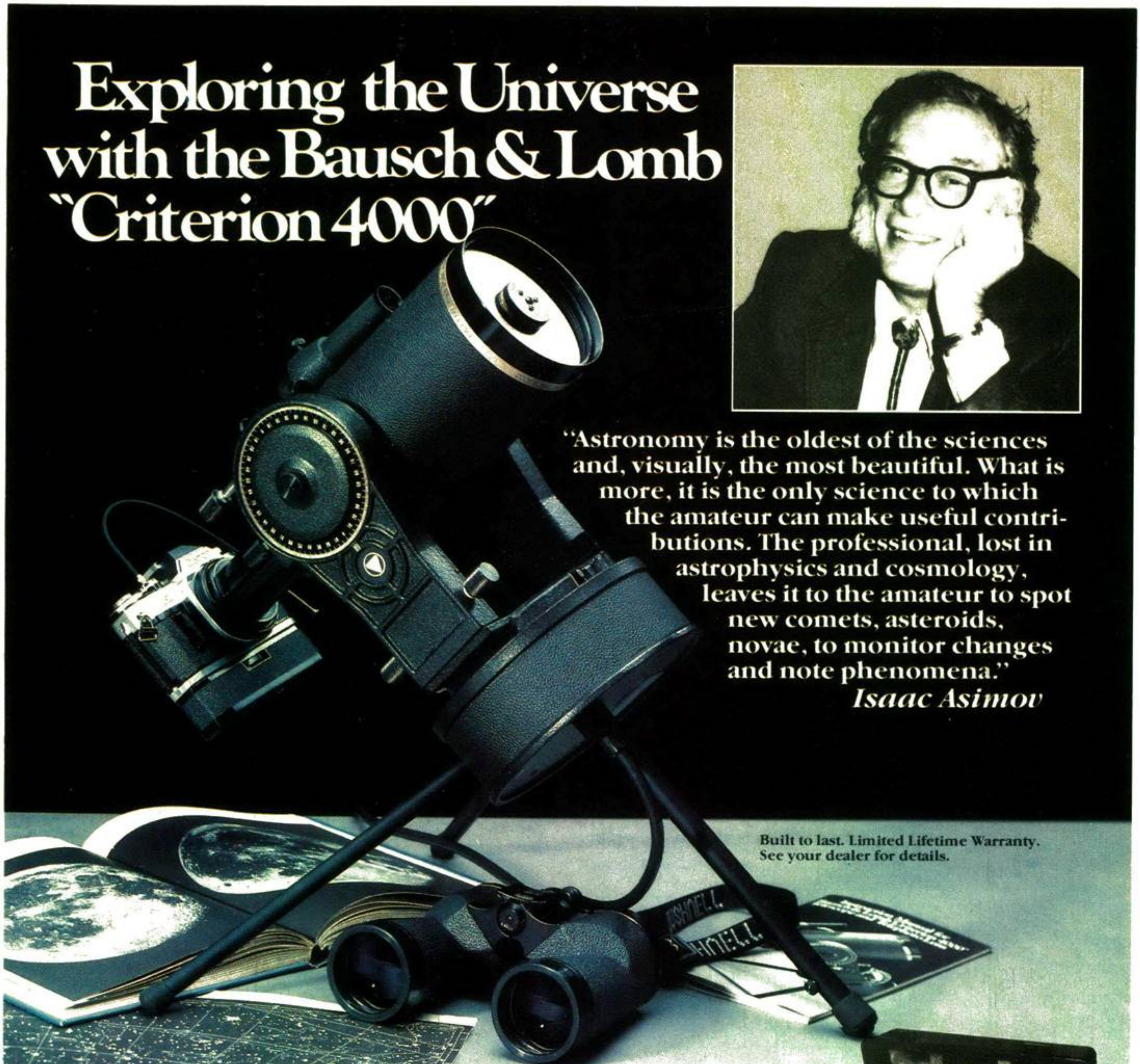
A typical research program would be like one they are doing for Doug Hall on RS Canum Venaticorum stars — stars that have large spots on them (see "Starspots," ASTRONOMY, February 1983). Hall's research needs massive amounts of data on many RS CVn stars. His computer analyzes the data statistically, puts sample spots on model stars, and calculates what the photometric record should look like. This is compared to the actual record, then the model is adjusted and rerun.

Commented Boyd, "There are a lot of photometric projects that can be done on a small telescope — and a lot that can't. For example, no one's done good photometry on the 50 brightest stars — *there's no data*! This is an area that small telescopes can handle beautifully."

Russ pointed out the some stars are well suited to the APT approach: "Long-period stars such as Mira-types are ideal. Observing every second or third night, a couple of APTs could really tear into several hundred of the brightest Mira's." But others are not so good. "On the short-period stuff, where the [telescope] system really has to sit on the star," he said, "APTs are not much more efficient — and probably in many cases less efficient — than manual systems.

"However, there's no ducking the point that APTs are a bit on the revolutionary side," he mused. "Once word got around about how the stuff Lou [Boyd] was doing for Doug Hall's RS CVn stars was only the tip of the iceberg — suddenly there was all sorts of interest. These guys are really competitive, and if a new mousetrap does better science, they don't waste time getting with the latest."

— Robert Burnham



Exploring the Universe with the Bausch & Lomb "Criterion 4000"

"Astronomy is the oldest of the sciences and, visually, the most beautiful. What is more, it is the only science to which the amateur can make useful contributions. The professional, lost in astrophysics and cosmology, leaves it to the amateur to spot new comets, asteroids, novae, to monitor changes and note phenomena."
Isaac Asimov

Built to last. Limited Lifetime Warranty. See your dealer for details.

Technical Specifications

Clear Aperture	4″
Dia. of Primary Mirror	4″
Secondary Obstruction	35mm
Cassegrain Focal Length	1200mm
Resolution Limit	1.1 ARC/SEC.
Useful Magnification	30-240x
Photographic Speed	F/12
Image Scale (field of view)	1°/inch
Faintest Magnitude	12
Unvignetted Field	1.850″ circle
Near Focus	15 feet
Finderscope	4x
Eyepieces	30mm, 18mm
Star Diagonal	1-1/4″

Exclusive Features

☐ Compact in size and weight (7″ x 7″ x 14″, and only 10 lbs!)

☐ Telephoto lens, long range microscope or astronomical telescope — all in one complete system.

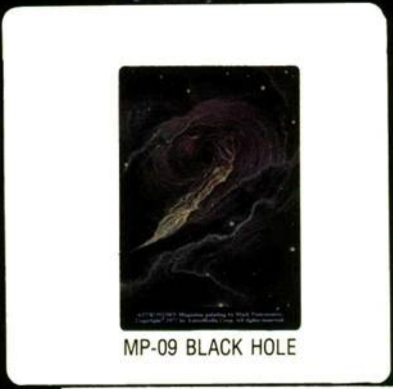
☐ Complete system includes: 120V.A.C. Electric Clock Drive for Astro-Photographic time exposures, 4X finderscope, two - 1-1/4″ eyepieces (30mm and 18mm), coated optics, star diagonal, fork mounting complete with precision setting circles, manual slow motions on both axes, power cord, carrying case and fully adjustable latitude legs.

See the "Criterion 4000" at fine Photo and Optical dealers or write Customer Service Manager for literature.

BUSHNELL
DIVISION OF **BAUSCH & LOMB**
2828 E. Foothill Blvd.
Pasadena, CA 91107 (213)577-1500

Explore the Universe from Your Living Room

These 4 sets of 35mm slides take you on a voyage of discovery into the universe. From the comfort of your home, you can explore our Solar System, thrill to the wonders of the Milky Way, and tease your imagination with glorious deep-space vistas by renowned space artists.



Imagination Turned Loose!

From its fantastic collection of dramatic, scientifically-accurate astronomical art, ASTRONOMY magazine proudly presents an artists' selection of unique images in color slide format. Perfect for illustrating lectures and talks, these four dozen slides can add that exciting "you are there" touch to any presentation. From the brown dwarf stars that may lurk in the vast distances between the stars, to a billion-years-ago eruption of the mighty Olympus Mons volcano on Mars, these slides are tops! Set includes works by artists Adolph Schaller, Mark Paternostro, Rick Sternbach, and John Clark. Descriptive brochure included. 48 slides (all color).

ASTRONOMY Space Art **$36.95**

6. LMC (N)
© 1982 Royer/Space Graphics

Explore Interstellar Space

Under the dark skies of southern California and Australia, astrophotographer Rev. Ronald Royer employed special color separation techniques to record the delicate traceries of celestial gas and dust in our Milky Way Galaxy. The result is this fine set of 35mm jumbo slides, originally presented to lecture audiences around the United States, now reproduced by Frank Holmes Laboratory and released for general distribution through AstroMedia. Comes in a vinyl binder complete with a descriptive text. 60 slides (all color).

The Milky Way in Color **$39.95**

Crescent Saturn
38
SOLAR SYSTEM CLOSEUP/MORRISON
ASTRON SOCIETY OF THE PACIFIC

Astronomical Society of the Pacific

Voyages of Exploration
Solar System Close-Up

60
Moon: Apollo 15 Landing Site
Solar System Set 2 / Morrison
Astron. Society of the Pacific

Part 1

Voyager, Viking, Mariner, Pioneer, Venera — you too can own fabulous images from humankind's exploration of the Solar System. Selected from NASA's image archives by Dr. David Morrison, noted planetary scientist and president of the Astronomical Society of the Pacific, these fifty slides bring the new era in Solar System exploration right into your living room! Perfect for the inquisitive layman — or put on your own astronomical slide show! 50 slides (24 in color).

Solar System — 1 **$34.95**

Part 2

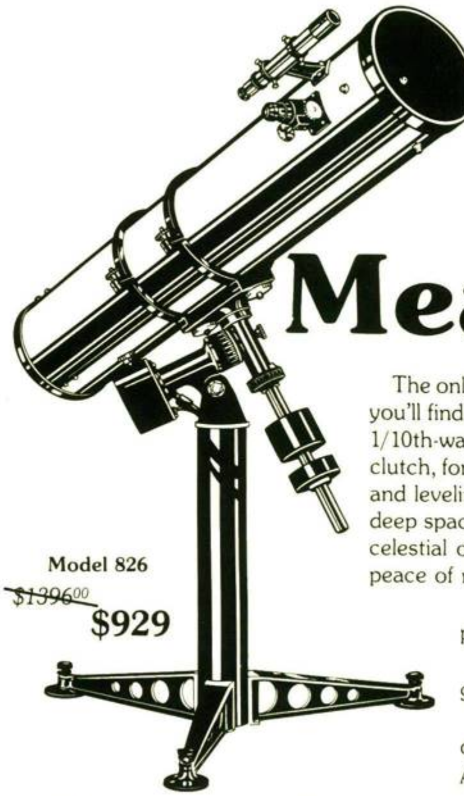
"When Dr. Morrison selected his first set of fifty slides, he and the A.S.P. staff agonized over all the magnificent views we had to leave out." That's how the Astronomical Society of the Pacific came to release Part 2 of their fabulous Solar System Close-Up slides. Fifty new images; no duplicates with Part 1. Includes the Soviet color images of the surface of Venus, spectacular vistas of planet Earth, and the satellites of Saturn. 50 slides (25 in color).

Solar System — 2 **$34.95**

Each A.S.P. slide set includes a descriptive booklet.

SAVE! Order both Solar System sets for only $62.50!

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.



Model 826

~~$1396^{00}~~

$929

Save a third on top-quality Meade® telescopes!

The only reflector telescope better than a Meade reflector is a Meade reflector at the 33% savings you'll find at Ad-Libs Astronomics! Just consider the standard equipment you get with a Meade — 1/10th-wave optics for textbook-perfect images; precision worm-gear electric drive, with automatic clutch, for effortless visual and photographic tracking; a turnbuckle latitude adjuster, latitude scale, and leveling screws for quick and easy polar alignment; two quality eyepieces designed for both deep space and lunar/planetary observing; a finderscope and setting circles to make locating faint celestial objects exceptionally easy; rotating tubes for observer comfort; a *lifetime warranty* for peace of mind; and even more! Just look at these savings . . .

Model 628, 6" f/8. An all-around scope. Ideal for the beginner, but with enough performance for the serious observer, too. *$1226 list* . . . . **for only $809**, freight paid!

Model 645, 6" f/5. Fast focal ratio ideal for deep space observing and photography, but great for planets, as well. *$1240 list* . . . . **for only $819**, freight paid!

Model 826, 8" f/6. A big scope, in both aperture and performance, ideal for the serious observer and photographer. *$1396 list* . . . . **for only $929**, freight paid!

All prices good through 6/30, but subject to change without notice. Freight additional on credit card orders.

Save on Schmidt-Cassegrains, too!

The famous Meade 2080 8" Schmidt-Cassegrain, the state-of-the-art quartz controlled 2080/LX3, the truly portable 10" Meade 2120/LX3 — they're all priced to save you a third at Ad-Libs!

Precision worm gear drive is standard on all the 8" and 10" Meade Schmidt-Cassegrains, as is a host of accessories and luxury features. Best of all, each Meade telescope is fully protected by Meade's *lifetime warranty!* You could still be enjoying your Meade Schmidt-Cassegrain the *next* time Halley's Comet stops by! Just look at these savings . . .

Model 2080, with wedge, tripod, two eyepieces, finder, worm gear drive, slow motion controls, setting circles, *lifetime warranty*, and more! *$2250 list* . . . . **only $1499**, freight paid!

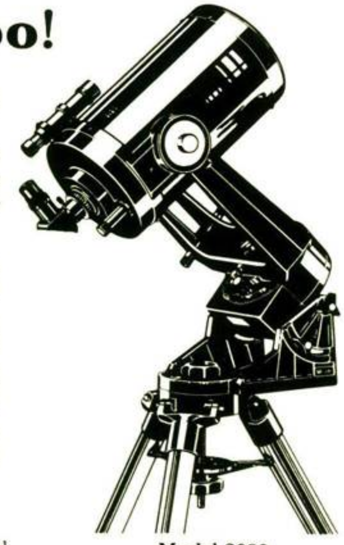
Model 2080/LX2, adds to the 2080 package an ultra-precise LX worm drive, larger finder, coated corrector, and premium eyepieces. *$2450 list*. . . . . **only $1649**, freight paid!

Model 2080/LX3, is the world's premium 8" Schmidt-Cassegrain. Quartz drive, illuminated finder, AC or DC operation, much more! *$2800 list* . . . . **only $1849**, freight paid!

Model 2120/LX3, the premier truly portable large aperture Schmidt-Cassegrain. With quartz drive, AC/DC operation, features galore! *$4500 list*. . . . . **only $2799**, freight paid!

And on Deep Space telescopes!

The **Meade DS-10A** is the most popular equatorial-mount fast focal ratio scope around — and with good reason! With motor drive, setting circles, #680 focuser, 25mm eyepiece, and *lifetime warranty*, this 10" f/4.5 marvel lists for $1510. Your cost at Ad-Libs? **Only $999**, freight paid!



Model 2080

~~$2250^{00}~~

$1499

Authorized Meade Dealer

Similar big savings on other brands, too!

Not only will we save you money on *all* Meade telescopes and accessories, but we'll save you money on other major brands, as well!

We stock Celestron, Questar, Bausch & Lomb, TeleVue, Edmund, Lumicon, Unitron, Coulter, University Optics — and even more!

Send a stamped, self-addressed envelope for our *free* discount price list showing your savings on the more than 70 telescopes and 500 accessories we carry — or send $1 for our complete catalog that takes the guesswork out of picking the right telescope, and saves you money, too!

ad-libs
astronomics Our 6th year of saving you money!
2401 Tee Circle, Suite 106, Norman, Oklahoma 73069 *(405) 364-0858*
MasterCard, Visa, American Express. Freight additional on credit card orders. North American sales only.

ASTRONOMY
In Focus

A Khaki NASA?

Sir / In his February Forum article ("Is NASA Being Militarized?"), James Oberg makes a number of valid points concerning the role of military personnel "on loan" to a civilian agency, but he seems not to have considered the importance or possible validity of different ways of perceiving the set of facts he presents to bolster his case. In addition, his closing remarks show a dangerous disregard for the two most important military lessons of the century.

First, the problem of alternative perceptions. I do not believe that NASA is now, or is ever likely to become, a pawn of some sort of military cabal. Yet look at Mr. Oberg's own figures: between 1978 and 1983, 51% of satellite launches from Vandenburg AFB and 37% from Florida were military — a total of 49 out of 113 expendable booster launches or 43%. But these weren't all NASA launches! Over at least part of that time span the Shuttle wasn't available, so most of those military launches had little to do with NASA personnel or resources. Therefore the percentage of pre-Shuttle military NASA launches must have been minimal. The rise from nearly none to one-third of all military launches from the Shuttle in 1987-88 is a drastic increase.

Consider this analogy. If you were driving along on our "national land transportation system" and noticed every third vehicle was military, would you have cause for concern over how tax dollars — dollars earmarked for a supposedly "civilian" purpose — were actually being spent? Especially when you discover that the needs of troop and material movement were considered primary design parameters of the system? What might foreign observers conclude as they rode along such a khaki-dotted highway?

If space travel is always going to be on the order of travel to the Antarctic, I have no qualms about major involvement with the military. But some of us have slightly larger plans. After all, Isabella did not send the Armada to the New World; she sent merchants. And she let Columbus hire his own bodyguards.

Of course, the DOD has hardly quelled the perception of militarization with its heavy-handed attempt at total secrecy surrounding the January 24 flight of Discovery. The actual launch of the reconnaissance satellites need not have been compromised by accommodating media coverage of the mission. Instead, we were treated to the spectacle of an American attempt to mimic the typical Soviet approach to news, an attempt which surely did nothing to prevent the Soviet tracking of the entire mission from both ground and orbit.

But my real concern is with Mr. Oberg's closing paragraphs. True, the Space Shuttle itself cannot be used as a weapon. That's not the worry. The Shuttle is supposed to be a truck. As such, it will be central to the construction and maintenance of any major military systems above the atmosphere. Such systems are part of most military planning for the next 50 years, on both sides.

Mr. Oberg states that ". . . [p]utting 'laser cannon' aboard [a Shuttle] is also a nitwit idea, as is the oft-repeated nonsense about placing thermonuclear warheads into orbit. Besides being illegal, such activity makes no practical military sense." Equally ridiculous is arming the Shuttle with laser or particle-beam weapons. But one major avenue of Strategic Defense Initiative (a.k.a. "Star Wars") research involves permanent fortresses of such systems in orbit. These would (by law!) be ferried up by the Shuttle. Beam weapons may be effective only in a vacuum, especially given inexpensive solar power by the square mile. The fact that such "fortresses" would be indefensible hasn't deterred the planners.

In addition, the desirability of placing thermonuclear weapons in orbit should not be dismissed so lightly. It can be argued that there is practical military value to such weapons, and that these can best be utilized from low-Earth orbit. I'm speaking, of course, about the electromagnetic pulse (EMP). EMP effects have been studied for over 20 years. In 1962 when the U.S. exploded the first atomic weapon in space over Johnson Island, streetlights and telephones were knocked out almost 800 miles away in Hawaii.

A few medium-sized thermonuclear devices exploded 200 miles above either superpower would effectively halt that nation's communications. It would also knock out power. The submarines and "hardened" underground bases would be relatively unscathed. So would people. But there would be no phones. No mass communication. No electric power. No motors of any kind — the EMP would stop it all. Then, if you were quick, you could move in occupying troops, leaving the opposing force the choice of either bombing its own population and cities or surrendering.

While the primary effects of nuclear weapons remain dirty, messy, and counter-productive, their utility in an actual war is low. But if a potent, cleaner alternative (orbital detonation planned for maximum EMP effects) were feasible, it would be included in military planning. And the Space Shuttle is the designated transport system to orbit for the military. No, James Oberg, thermonuclear weapons in orbit are far from nonsense.

As for the other major military discovery of the twentieth century — the legality of it all — I have a one-word reply: Belgium. I suggest that anyone interested in the force of international law read up on German actions at the start of both World Wars. These same episodes should also point up the criticality of the perception, real or imagined, of military mobilization in precipitating conflicts.

Andy Sincinito
Mt. Sinai, NY

Watching Satellites

Sir / I enjoyed Larry Sessions' article on observing artificial Earth satellites (June 1984). Unfortunately, the satellite section of the British Astronomical Association — mentioned as a source for tracking data and identifying observed satellites — has been defunct for two years. In corresponding with them, however, I was told they may restart their satellite section in England and, if funds are available, expand it to other countries.

One of the few sources of tracking data for satellites now available is AMSAT, an organization of amateur radio operators who build their own communications and scientific satellites. AMSAT gives out satellite data at 3855 kilohertz shortwave at 9 p.m. local time Tuesday evenings.

But even without tracking data, you can identify some satellites. Try for Pageos. It travels in a 2000-mile-high polar orbit, and typically appears as a second to fourth-magnitude star that moves so slowly you could mistake it for a nova.

Also interesting is the world's only space station — Russia's Salyut — identifiable by its diagonal track across the sky as seen from middle latitudes. As Sessions mentions, a satellite's inclination angle determines its visibility; since Salyut's inclination is 51.6°, it is easily visible across the United States. Salyut looks like a zero or first-magnitude star-like object traveling fairly fast. You may also see one of the manned Soyuz or unmanned Progress tanker craft after they undock from the space station and travel in a similar orbit for a while before returning.

The Shuttle is also visible when up — at least from some places. Most missions head due east from Cape Canaveral (latitude 28.5°) and reach only about 200 miles altitude, therefore only the southern United States and countries near the equator are well placed for viewing. The next mission planned to head north and be visible over Europe and the northern United States is the second Spacelab mission, due in April 1985. AMSAT, mentioned above, is currently giving predictions for Salyut and the Shuttle.

Some astronomy clubs are working on computer programs that use satellite observations for more accurate predictions. This summer's Turnpike Astronomy Conventions in Ohio should provide many observations to test our tracking procedures.

L. Michael Poda
Akron, OH

Keeping Your Castors Un-Polluxed

Sir / I enjoyed the idea of imagining Polaris as a celestial "caster" so as not to "Pollux" up remembering which bright star in Gemini is which (February 1985 Eye on the Sky).

My own technique utilizes the observation that Castor and Capella begin with C, and that Pollux and Procyon begin with P. Castor is on the Capella side of Gemini and Pollux is on the Procyon side.

It might be fun to read what memory aids other readers use. These could also liven up local astronomical club meetings.

Donald W. Low
Fenton, MO

Catacomb Painting

Sir / The last part of the discussion on the "Star of Bethlehem" (AstroNews, February 1985) appears to draw an incorrect conclusion. It is not clear that all supernovae leave behind pulsars. None has been found at the site of either Tycho's or Kepler's supernovae, even though both are of more recent origin than the Crab nebula. There are also two different kinds of supernovae in other galaxies, and there may be more pulsars than supernovae could possible have formed. See Rudolph Kippenhahn's *One Hundred Billion Suns*.

We are left with the paradoxical situation that there appear to be two separate and distinct types of supernovae, one of which results in a pulsar while the other does not. Further, there may be another mechanism for the production of pulsars about which we, as yet, know nothing.

Stanley Wallen
Lewisville, NC

Behind the Scenes

A New Observing Season

For those of us who live in places that get cold in the winter, May marks the transition from bone-chilling nights to the "warm" season where no more than a heavy coat, sweater, and Thinsulate gloves are needed to keep an observer cozy all night long. Every day the Sun sets a little later and nights get shorter. The last of winter's bright stars slip into the glow of the west.

For us midwesterners, spring night air is a rich mix of last year's rotting vegetation, damp soil, and the smell of new plants growing. In drier, more southerly places, the season is further along. Aromatic creosote bushes and sage have returned to life; the desert blooms. In the mountains, the snow has melted away — except for the deepest drifts and the temporary cover of a late blizzard or two. Here, too, a new observing season has begun.

Evocative, beautiful, inspiring? Yes, it is all this and more. But there is nothing *comfortable* about spending a night under the spring stars. Here, at any rate, everything soon gets drenched with dew. Feet become wet, then cold, then numb. Charts and books go soggy. Eyepieces fog up.

Sometime after midnight, your body will start to tell you that you should be home in bed. Operating on half your wits, you'll look at the sky with no enthusiasm for seeing another galaxy or globular cluster or planetary nebula or any of that stuff at all. Muscle aches and joint pains will set in. If you persist, it will be because of a sound observing methodology or from following a well thought-out observing plan. You know your observing notes will look incoherent in the morning.

If you are determined, you will stay up all night. Alone. Alone with the whole universe over your head, trying desperately to make sense of the faint smudges of light you see in the eyepiece, trying to remember what you've read that makes this or that blob worth looking at. Then you have to wait through the dawn to see the Sun come up.

Appreciating astronomy takes a few all-nighters; their effects may last years. You have to confront the cold and wet, the exhaustion of the wee hours — and then emerge from it as the stars of summer rise, to stare enthralled by ruddy Antares through a dripping wet telescope with eyes full of sand.

Sincerely,

Richard Berry

Richard Berry
Editor-in-Chief

focus

CAMERA INC.
4421 - 13th Ave., Brooklyn, N.Y. 11219
Dept. 05AS

ENJOY ASTRONOMY AT DOWN-TO-EARTH PRICES

- *Large Inventory*
- *Huge Savings*
- *Immediate Shipping*
- *Personalized Service*

CATALOG OUR NEW 96 PAGE WINTER CATALOG FEATURING THE LATEST IN PHOTOGRAPHICS & ELECTRONICS $3

CALL TOLL FREE Except AK, NY & HI **800-221-0828** For Orders Only

Ask for Bob or Mark our telescope experts

For Information, AK, NY & HI **718-436-6262**

Satisfaction Guarantee: refund or exchage within 14 days (less shipping) if returned in original **MINT CONDITION** with all papers (as shipped)
Customer Service 718-871-7608

FREE Professional Optical Maintenance Kit With Purchase ($18 Value) w/this clipping

FOCUS CAMERA & ELECTRONICS has been serving customers nationwide with all their photographic needs for over 16 years, with a solid reputation for integrity. We invite you to join our hundreds of thousands of satisfied customers. Give our knowledgeable sales staff a call TODAY! **AND SAVE!!**

CELESTRON

PRECISION OPTICS

WORLD'S FAVORITE!
SUPER C8 PLUS

- 8" Aperture
- 480 Power
- Gathers 791 times more light than the eye
- Ultra precise gear drive

Complete outfit w/Oculars, Finderscope etc. as supplied by the manufacturer.

CALL

SUPER POLARIS C8 W TRIPOD $799

Sky Sensor Computing Control	399
Comet Catcher Jr	219
Celestron Comet Catcher	299
Case for Comet Catcher	38
C65 Spotting Scope	139
Delux Zoom Ocular	92
C90 Spotting Scope Outfit	319
C90 Astro Telescope w/Clock Drive	499
C5 Telescope	769
C6 Newtonian Reflector	549
C11 Telescope	Call

COMETRON 50 BRASS

- Elegant, Solid Brass
- 40 Power
- w/Pedestal & Stand

$247
(Retail $450)

SKY WATCHER

- 25mm Eyepiece; 12X
- Finderscope & Star Diagonal Included
- w/Table Top Tripod

$199.90

CELESTRON ACCESSORIES

C8-C90 Adjustable Tripod	159 90
Photographic Tripod	78 00
2X Barlow Lens	26 90
Celestron Sky Maps	13.90
Solar Filter	99.50
Wedge C8-C90	59 90

Large Assortment of Oculars in Stock

CELESTRON ZOOM MASTER

12X to 60X ZOOM SPOTTING SCOPE
- High Tech Black Finish
- Exceptional Precision
- w/Tripod Adapter & Gift Box

Retail $320
$199.90 SUPER-SALE

Camera Adapter $31.90

★ CELESTRON ANNIVERSARY SALE ★

C80 REFRACTOR

- 910mm Effective focal Length
- Gathers 130X More light than the human eye
- 1¼" Ocular for Wide Field of View
- Equatorial Mount w/Circle Settings

$459.90 W/tripod

FIRSTSCOPE 80

w/Azimuth Mount & Tripod	$339.90
Super Polaris 80mm Refractor (accepts Sky Sensor)	$595.00

ACCESSORIES:

Quartz Motor Drive	$109.00	2X Barlow Lens, Dlx	$52.00
Polar Axis Finder w/Illuminator	$58.00	Piggy Back Mount	$34.00
Sky Maps	$14.90	Camera Adapter	$26.90

TOP RATED CELESTRON C6 NEWTONIAN

- Huge Light Grasping Ability
- Multicoated for 20% Brighter Images
- 750mm Effective Focal Length
- 28" long, 50 lbs
- 45Xmore light Gathering Ability than the Human Eye

$549.90 w/Tripod
& Free Subscription to "Deep Sky"

Nikon BINOCULARS

The Famous Nikon Optics Are Your Best Assurance For Clear And Crisp Images

9x25-CF Compact	49
7x35-E High Eyepoint	116
10x35-E High Eyepoint	128
7x50 Standard High Performance	149
10x70-IF	288
8x20 Roof Prism	112
Nikon Spotting Scope with 20x Eyepiece	198
8x30 Rubber Coated	156

ZEISS

- THE ULTIMATE IN PRECISION
- MULTI-COATED T* OPTICS
- UNSURPASSED BRILLIAMT BRIGHTNESS

6x20B/IF **160** 8x20B	187	8x30 B/CFT* Armored	396
8x20IF	168	10x40B/CF T*Dialyt	449
10x25B/CF	197	7x50B/IF **596** 7x42B/CF	422
8x30 B Dialyt Standard B/CF/T*	367	8x56B CF T* Armored	536
		10x40B/CF Armored	478
8x30 B/IF Armored	337	15x60 CF T* Porro	827

Leica TRINOVIDS

Conditional Lifetime Guarantee
- The Singular Choice of Those Who Demand the Absolute Best
- Perfect for Eyeglass Wearers
- Conditional Lifetime Guarantee
- Climate, Dust, Spray — Waterproof
- Armored Models are Resistant To Impact and Shock
- Every Detail Becomes Vividly Real

10x40-B	414*	8-20-BCA Armored Compact	175*
10x40-BA Armored	448*	10x25-BCA Armored Compact	189*
7x35-B	284		
7x35-BA Armored	308		

**Price includes $25 or $100 Rebate*

CELESTRON

PRECISION OPTICS

GIANT BINOCULARS

- Perfect for astronomy & low-light viewing
- Glare-free viewing & no eyestrain
- Exceptional image quality
- 25 year warranty

11x80	209
20x80	229
30x80	239

BUSHNELL

DIVISION OF **BAUSCH & LOMB**

SPACEMASTER OUTFIT:
- SPACEMASTER 60mm
- 15-45X Zoom Eyepiece
- Table Tripod
- Attache Case

$214.90 Complete Outfit

Discoverer with 15x-60x Zoom Eyepiece	209
Camera Mount	24
Spacemaster #1800	139
Eyepieces	All in Stock

BUY SOMETHING WORTH LOOKING INTO THE CRITERION 4000

BUSHNELL DIVISION OF BAUSCH & LOMB

- Compact 7"x7"x14" weighs 10lbs
- Includes Finderscope, 2 Oculars & Adjustabale Legs
- 1200mm Effective focal Length
- With Electrical Clock Drive

$485.90

Criterion 6000 Telescope Kit	$789.00		
Criterion 8000 Telescope Kit	$939.00		
Criterion 4000 Telephoto Lens	$289.00		
Porro Prism	$37.00	Nebula Filter	$71.00
2X Barlow Lens	$27.00	Camera Adapter	$21.00

Authorized Meade Dealer

A WHOLE LOT MORE THAN MEETS THE EYE

LIFETIME WARRANTY

SUPER SPECIAL! BEST SELLER! THE IDEAL SPOTTING SCOPE FOR VIEWING HALLEY'S COMET **199⁹⁵** w/CASE

MEADE 87D
- 1000MM EFFECTIVE FOCAL LENGTH
- 49X MORE BRIGHTENSS THAT THE HUMAN EYE
- 40X & 83X EYEPIECES INCLUDED

3.5" Model 97D Spotting Scope with 5x24mm Viewfinder

#97D 1000MM F11 with Finder, Star Diagonal, 2 Eyepieces (40X, 89X)	$295.90
Erecting Porro Prism	$46.00
Table Tripod	$34.00
#107D 4", 145X Human Brightness, F/10 Focuses Down to 15 ft	CALL

INTRODUCING THE FAMOUS SCHMIDT-CASSEGRAINS from Authorized Meade Dealer

8" MODEL 2080
- Best Seller Astronomical Telescope for the Serios Amateur
- Tremendous Light Gathering Capability
- Supplied w/Electric Motor to Automatically Track Astronomical Objects

Outfit Includes Star Diagonal, 2 Eyepieces (80X & 222X), & 6x30 Finderscope $875.90

8" **#2080/LX** Features **ULTRA-PRECISION** Drive System **CALL**
8" **#2080/LX2** With High Transmission Starbright Coating, 7mm (286 Power) Ocular & 8 x50 Finderscope **$1079**
#2044 4" With 9mm & 25mm (111X & 40X) & Table Tripod **$697**

ACCESSORIES:

Wedge	$65.00	8" Field Tripod	$198.00
Sky Map	$15.90	Tele-Extender	$25.00
8" Solar Filter (For Safe Observation of the Sun)	$198.00		

MEADE DEEP-SPACE SERIES:

DS-10, 10" w/46X Eyepiece, 46" long, w/Equatorial mount & Tripod Legs **$669.90**
DS-16, 16" w/73X Eyepiece 68" long, complete Kit .... **CALL**

SWIFT

SPOTTING SCOPES & BINOCULARS PAR EXCELLENCE
(All w/Tripod Socket)

11x80 GIANT CF	$179.90
20x80 CF WIDE ANGLE GIANT	$195.00
Photographic Tripod	$44.90

SPOTTING SCOPES:

#840 Lynx 20-60 x65 Spotting Scope	$439.90		
#841 15-60 x60 Spotting Scope	$229.90		
#844A 20x60 Armored Commando Spot.Scope	$179.90		
Swift Tripod	$54.00	Attache Case	$39.00
Tubular Case	$19.00	Camera Adapter	$18.00
Skylight Protective Filter	$8.90		

FOCUS CAMERA INC. 4421 13 Ave., Brooklyn, NY 11219
Dept. 05AS
Orders: 800-221-0828
Information: 718-436-6262
Customers Service: 718-871-7609

Orders shipped promptly—Mastercard, Visa gladly accepted. You may use your American Express card. No surcharge on Visa/Mastercard. We accept C.O.D. orders. Add estimated charge for shipping, handling & insurance. Written inquiries welcome. Not responsible for typographical errors. HOURS: Mon-Thurs 10-7/Fri 10-3/Sun 10-6. All merchandise avail. at prices shown while supplies last.

Southern Schmidt Photos

Photography in Astronomy

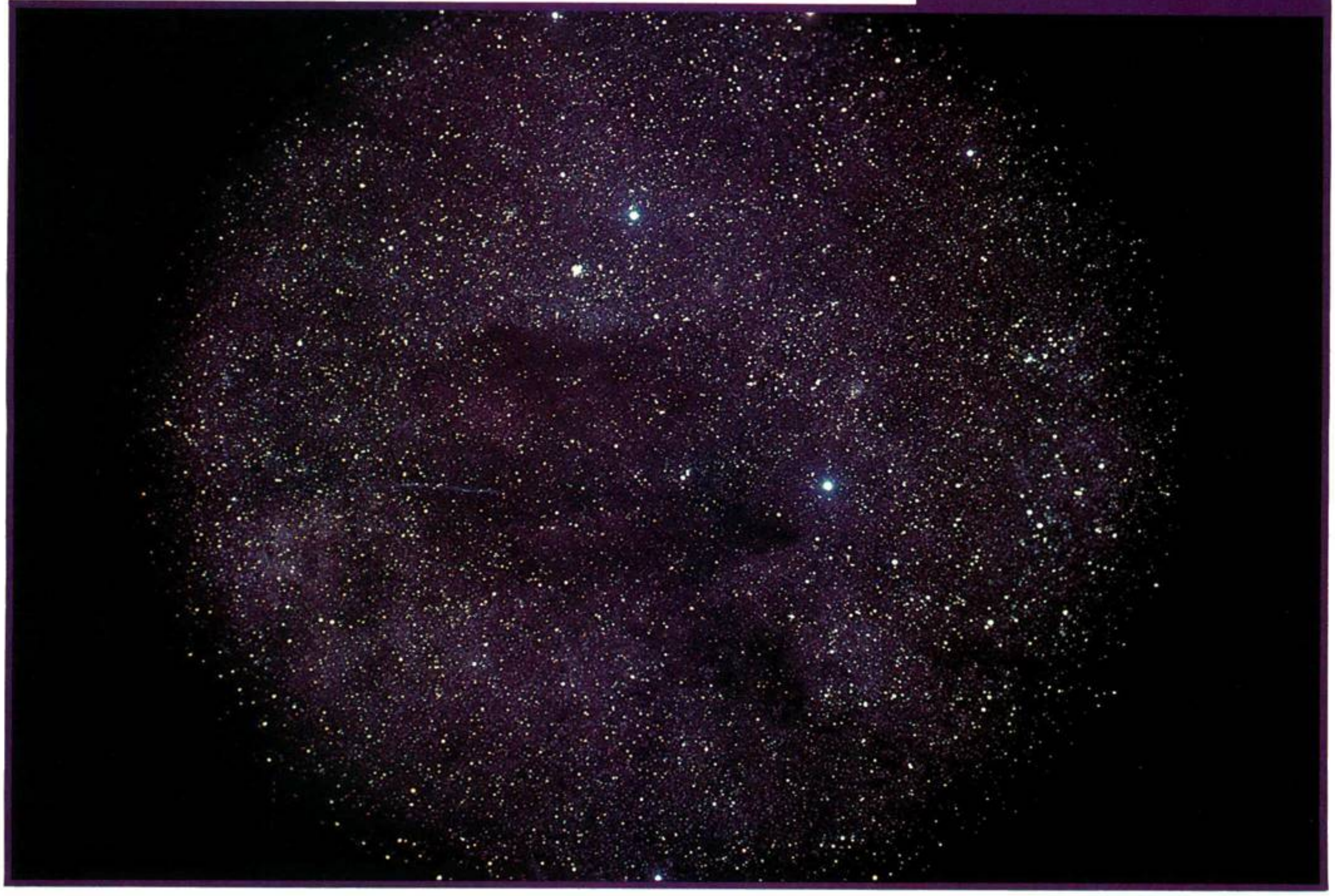
by
Stephen Edberg

Way back in 1974, I studied solar physics in hopes of becoming an astronomer. Naturally, when I had the chance to travel to Australia to see that year's total solar eclipse, I jumped at the opportunity. During my visit, I did some work for the Mount Stromlo and Siding Spring observatories.

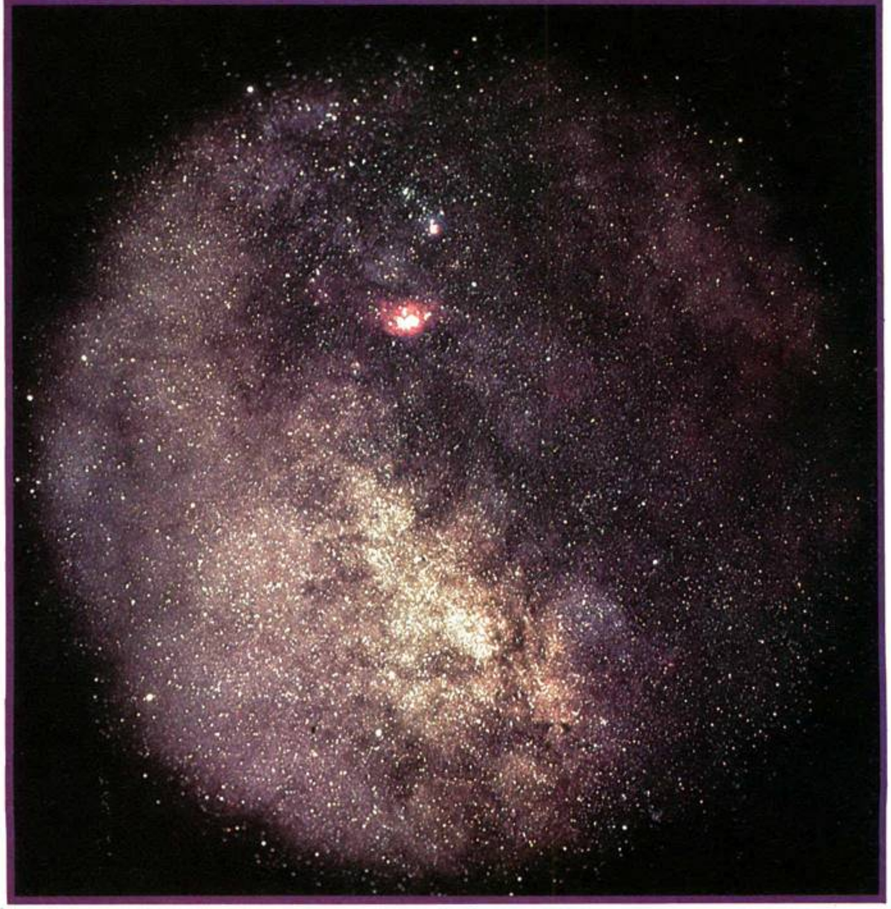
Located high in Australia's hills near Canberra, the observatory's main instrument is now the 3.8-meter Anglo-Australian Telescope, but that was not finished while I was there. The astronomers at Siding Spring equipped me with an 8-inch f/1 Schmidt camera so I could do wide-field photography. The camera used 120 roll film and employed a field-flattener, a device yielding crisp images of large hunks of sky. Wanting to take home souvenirs, I arranged to get some ISO 160 High-Speed Ektachrome film for the Schmidt. I made 10 and 20-minute exposures of the brightest objects in the southern sky, which are reproduced here.

Eleven years have since passed. But the images I came away with still bring back vivid memories of another place, another time — standing on Mount Stromlo, peacefully looking up at the universe.

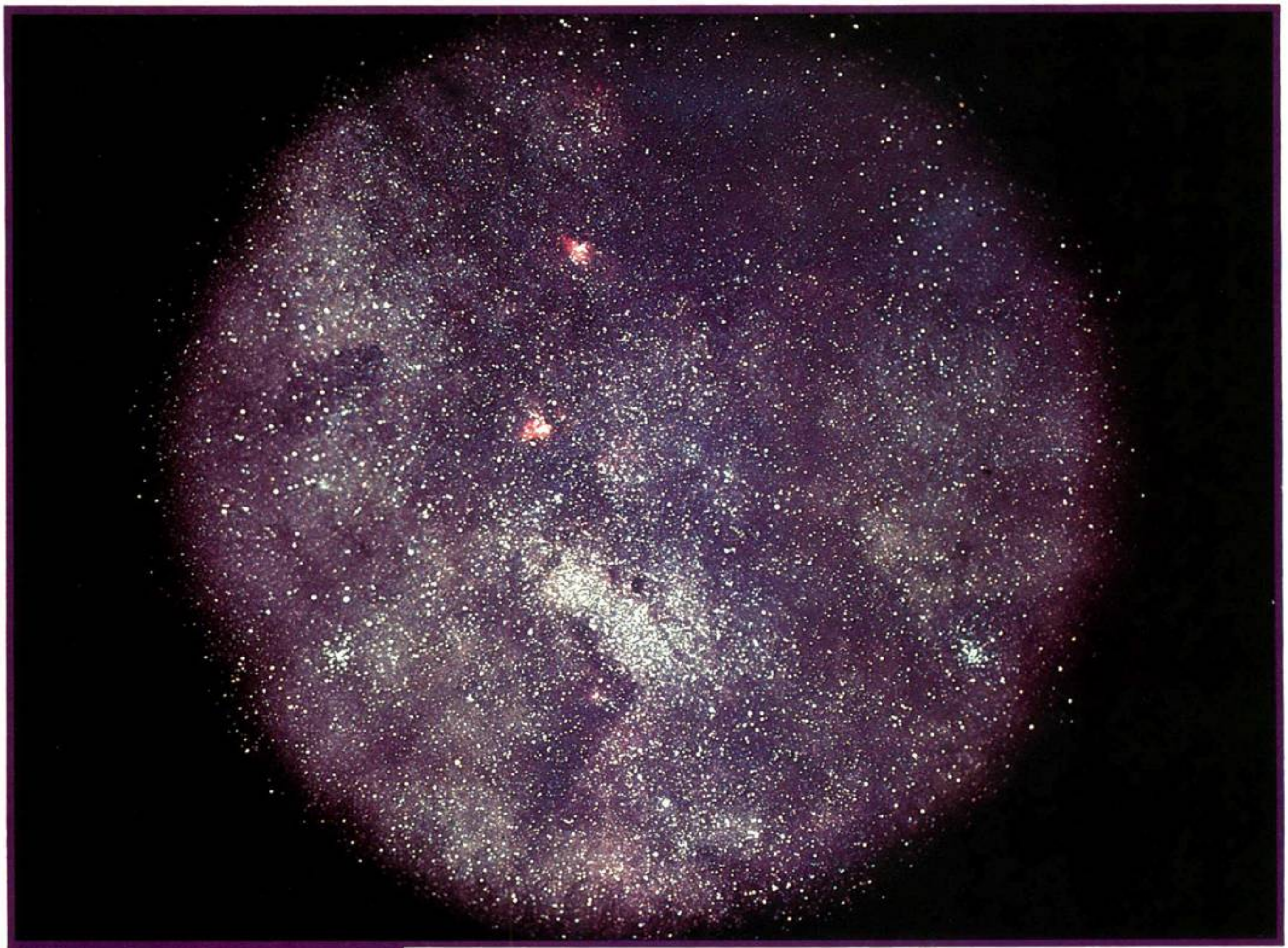
The southern sky's most prominent dark nebula, the Coal Sack, lies just southeast of Crux. The bright knot above center is the Jewel Box, a large open cluster. All photos by Stephen Edberg.



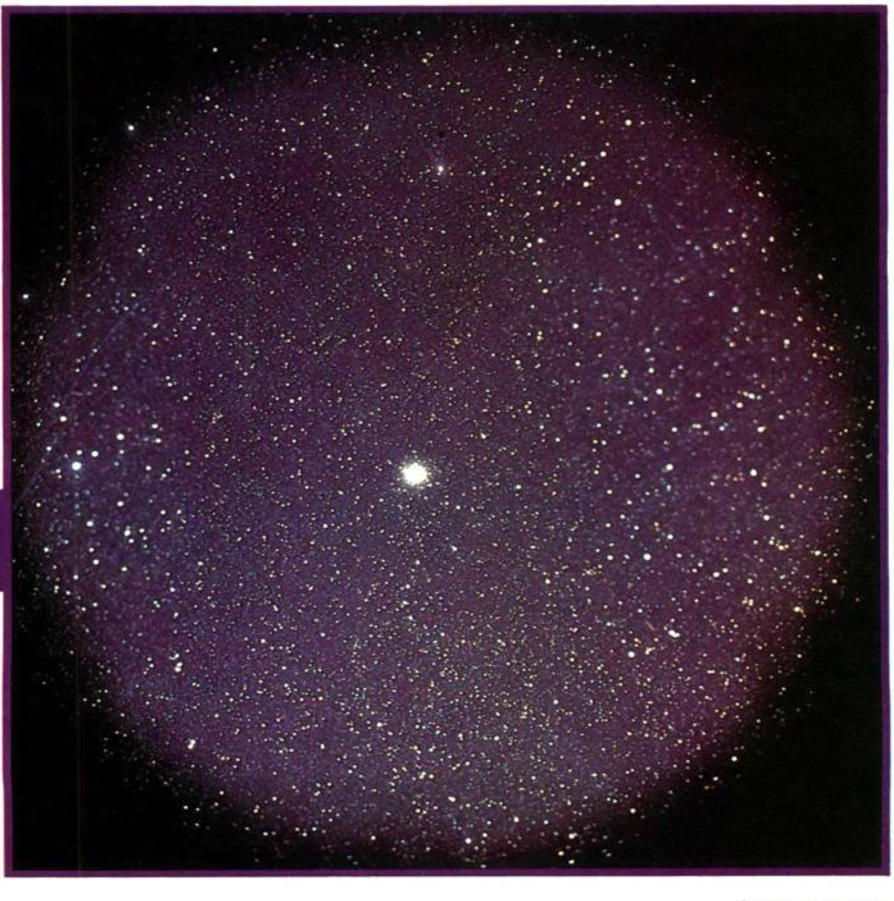
Central Sagittarius — toward the very core of our Galaxy — is filled with gas and dust; numerous star clusters pepper its field. At upper center are the Lagoon and Trifid Nebulae.



Visible to the naked eye as a hazy patch is the Eta Carinae Nebula, an HII region more impressive than M-42 in Orion. At left are the brilliant stars of NGC-3552; the rich cluster NGC-3114 lies at right, while the scattered group of stars IC 2602 lies at bottom.



Serpens and Northern Sagittarius contain innumerable stars. At top are the ruddy hues of emission nebulae M-16 and M-17. At lower center is the large star cloud M-24, which backlights distinct dark nebulae. On opposite sides of M-24 are the star clusters M-25 (left) and M-23 (right).



The great globular cluster Omega Centauri — the brightest such object in the sky — dominates this field in Centaurus. Also visible is the peculiar galaxy NGC-5128 (top center) and the tiny spindle-shaped spiral NGC-4945 (lower right).

ASTRONOMY
Reviews

The Solar System
Roman Smoluchowski
174 pages, hardcover, $27.95
W.H. Freeman (1984)

Taking advantage of newly-obtained data, information, and photographs, *The Solar System* is a well-written and timely book which will give anyone interested an accurate, up-to-date overview of our Sun and its family. The book, one in a series of single-topic volumes from the publishers of *Scientific American*, is a colorful glossy publication that attempts to synthesize major facts about the region of the Galaxy we call home.

The book is aimed at readers who are not so much concerned with mathematics and esoteric detail as with (in the author's words) ". . . a quick glance at the Sun and the planets and their moons and . . . the chance that there is life elsewhere in the solar system."

The volume is built around the fundamentals for understanding the solar system. Drawing heavily on information gleaned in the recent past, the author provides concise, non-technical explanations and descriptions of the Sun, planets, satellites, asteroids, comets, and meteors. Also included is a generous number of excellently-reproduced photographs, many of which will be familiar to ASTRONOMY readers.

In an attempt to separate factual information from theory and assumption, the author includes three appropriately-placed essays in the volume. These are "The Birth of the Sun," "The Formation of the Planets and Their Satellites," and "The Fate of the Solar System." Isolating supposition and theory in this manner is a helpful device to remind the reader that many fundamental matters are still mysterious — despite the flood of data we've received.

While logically organized, the book employs a slightly unusual approach for classifying the planets. After discussing the Sun's dynamics and how it maintains its equilibrium, the planets are categorized and described: "The Hottest Planets" are Mercury and Venus; "The Water Planets" are Earth and Mars; "The Giants" are Jupiter and Saturn. Then come "The Cold Planets" and "The Small Bodies."

Smoluchowski writes clearly and informally. "The Earth," he says, "is slightly oblate so that it has, like some of its inhabitants, a bulge at the equator."

He explains that Jupiter might have become a small star — a partner in a jovian-solar binary system — had its mass and diameter been somewhat greater. He gives a lucid explanation of the Oort cloud. We also learn that Comet Kohoutek slows to about one kilometer per hour at aphelion — and in five million years, when it again flashes by the Sun, it will be traveling at 500,000 kilometers per hour.

In his final chapter, Smoluchowski addresses the possibility of extraterrestrial life. He concludes that we are alone but leaves the door open a crack, stating that "civilizations may exist that are based on spatial or temporal or philosophical concepts different from ours."

This popular-level book could be considered superficial in that it covers the entire solar system in less than 175 pages. Experienced readers won't find much here that's new. Still, the book does what it was intended to do: explain the essentials of solar system astronomy in an attractive, easily understood format. *Gail O. Clark.*

God and the New Physics
Paul Davies
255 pages, paperback, $7.95
Simon and Schuster (1983)

This book is not for astronomers as such. Rather, it is for those with an interest in philosophy — more particularly metaphysics — and especially for those with an interest in theology. Astronomy adds only a bit of seasoning to the main course.

It's all here — quarks & miracles & the Big Bang & soul & quantum theory & time & black holes & "God" & relativity & free will & super-symmetry & mind & the anthropic principle & creation & galaxies — all thrown together in one indigestible stew. What makes it so unpalatable is the author's complete refusal to take into account the sharp disparity in thinking during different historical epochs.

For example, Davies begins his discussion of mind by stating: "I know of no religion that does not teach that God is a mind." I have a master's degree in theology and a doctorate in philosophy and literature, and I know of no religion before the work of the French philosopher Rene Descartes in the 1630s that would be able to make sense of that statement. Mind, like much of the rest of the modern world, was invented in the 17th century.

In another example, Davies states that the physics of the Big Bang has something to do with the story of creation in *Genesis* 1 to 3, not fully considering that the former attempts to ask *how* the universe came to be (i.e., the mechanism), while the latter considers *why* it came to be (i.e., the meaning). But these days, the word "why" has been pre-empted by science. When a child asks you why the sky is blue, he doesn't want an account of the physics of visible light being scattered by air molecules. He wants you to confirm his impression of the incredible color he perceives. There is confusion here between the two meanings of the word "why" — one scientific and the other religious/philosophical/literary.

Science is a peculiar activity. One fundamental aspect of it is much like poetry, as when a mathematician sits writing symbols on paper. But the mathematician's symbols are necessarily single in meaning, while the poet wants each of his symbols — words — to mean many different things at once. And math demands that the symbols be taken literally, while poetry would be quite unhappy with that. This is why the authors of *Genesis* 1-3 would be insulted that both scientist Davies and fundamentalist creationists take their profoundly beautiful writing literally. Only occasionally — as in Einstein's $E=mc^2$ — does math produce a vivid metaphor, while even an average poem had better have half-a-dozen of them.

The other fundamental aspect of science, which characterizes the actual work of almost all scientists and constitutes what is properly known as the scientific method, is the painstaking and grubby work of experiment and verification, the extremely difficult accumulation of sufficient data. Einstein's metaphor is like a successful pole-vault — exhilarating and it gets you there fast, but the method is extremely risky. The vast majority of scientific work is like crawling doggedly up a mountain, examining and re-examining each centimeter of ground along the way. Leaps of insight are essential — but they must be justified by slow and certain work, as indeed Descartes, who laid the foundations of modern science, intended.

What is involved here are two very different ways of knowing. The glory of science is that its knowledge has some certainty because it has been obtained by an almost deadening literalism. This is what enables science to discover such neat things. Literary or religious or philosophical knowing is brilliant — it flashes across the sky like a meteor. But such knowing is tricky: one is never quite sure. Things are evanescent, slippery, in flux (Herakleitos), unpredictable, uncertain, strange, and charming.

Neither Davies nor any scientist or mathematician I've read, including Einstein, seems to have fathomed this simple but important distinction. Thus Davies describes Werner Heisenberg's uncertainty principle as the beginning of a revolution — but it is such only for a literal-minded scientist, not for a human being in a quandary. Davies sees quantum theory's view of the unpredictability of phenomena as shocking, but the phenomena are unpredictable only at the most minute level.

Scientists make some peculiar errors when they get into areas in which they are not trained. They get trapped by their metaphors. The most glaring case in point, in this book and in astronomy as a whole, is all the sci-fi nonsense written about black holes. Mathematicians postulated these when their symbols forced them to focus on what they call singularities. Without getting into the extremely complicated matter of the relation between math and reality, suffice it to say that there is growing evidence that what the mathematicians call black holes are real. Of course, what exists at Cygnus X-1 is not a Schwarzschild (non-rotating) black *hole* at all, but a (spinning) black *sphere* around which one can orbit — if one carefully keeps one's distance. And with that realization, out the window goes all the sophomoric stuff about worm holes, alternate universes, and white holes.

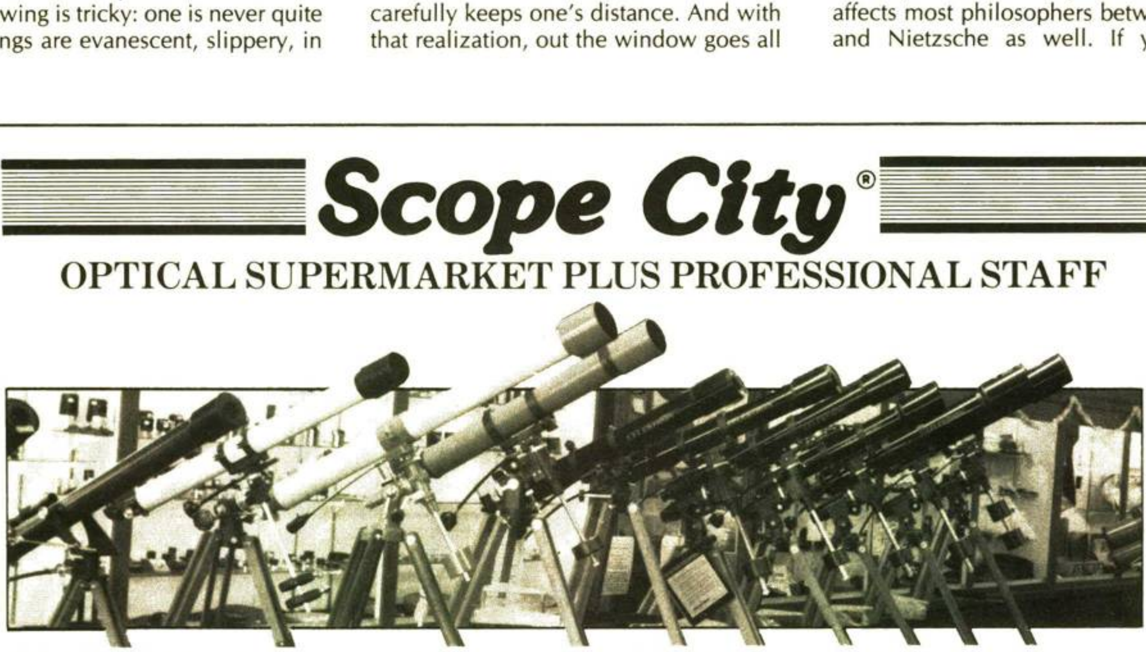
Not only does this make irrelevant the scores of speculative pages of meta-theologico-philosophy Davies spins out, but it gets in the way of new astronomical discoveries as well. There is clearly something *dynamic* about these black spheres — they pulsate, explode, eject jets, apparently engage in all kinds of energetic activity detectable at the various (non-optical) wavelengths astronomers are now able to explore.

The fundamental error of confusing different historical epochs and mixing different disciplines underlies many statements by Davies that I find completely insupportable. For example, he thinks that a computer might be more complex than an ant, that black holes and gravity waves are non-material, that math enables scientists to describe things beyond the power of human imagination, that life is unlikely in the universe, that "minds" other than our own can be known only by analogy, that there can be disembodied minds, that computers can be intelligent beings. (Like Jonathan Swift, George Bernard Shaw, and Mark Twain, I see no evidence that homo sap is an intelligent being — much less his machines.)

The problem is not just Davies' — it affects most philosophers between Plato and Nietzsche as well. If you're an

Scope City®

OPTICAL SUPERMARKET PLUS PROFESSIONAL STAFF



With millions of dollars of inventory, Scope City is the largest, most complete astronomical supermarket in the U.S.A. Here's why—

1. **We are optical specialists.** We offer nothing but optical instruments and accessories from large, well displayed and professionally staffed centers.
2. **We carry a huge selection.** You'll find our centers full of telescopes, mounts, accessories, telescope-making supplies, astrophotography aids—plus an immense selection of binoculars, spotting scopes and telephoto lenses. And you'll find all the biggest brands—Celestron, Meade, Bausch & Lomb/Bushnell, Parks, TeleVue, Lumicon, Edmund Scientific, Zeiss, Leitz, Swift and more.
3. **We stand behind our products.** We're professionals who will be around to help you whether you buy from us or not. We guarantee everything we sell. Our customers include universities, research institutions, NASA, JPL and the U.S. Government.
4. **And more.** We offer a lay-away plan and accept trade-ins. We repair telescopes and binoculars. We sell to the world. And we export telescopes for all voltages and frequencies.

SEND FOR A FREE CATALOG.

($5/U.S. for all foreign.)

VISIT THE LARGEST AND MOST COMPLETE TELESCOPE AND BINOCULAR CENTERS IN THE U.S.
THREE LOCATIONS TO SERVE YOU:

Costa Mesa, CA
3033 S. Bristol (San Diego Fwy. to Bristol Exit, 2 blocks south)
(714) 957-6900
Mon-Sat 10-7, Sun 11-5

Simi Valley, CA
679 Easy St. (Simi Fwy to First St. Exit, So. ½ mile, right on Easy St.—2 blks.)
(805) 522-6646
Mon-Sat 9-6

Torrance, CA
3132 Pacific Coast Hwy. (San Diego Fwy. to Crenshaw Exit So., W. on PCH, 3 blks.)
(213) 326-3251
Mon-Sat 10-7

MAIN OFFICE AND MAIL ORDER:

Scope City
679 Easy Street
Simi Valley, CA 93065
(805) 522-6646 Mon-Sat 9-6

MC/VISA

Scope City

astronomer with a religious or philosophical bent, I can't help you. I know of no books I would recommend. Perhaps you might do what I have done — give it up altogether for poetry and music, and observing the heavens. There you might find the original meaning of the word philosophy — "the love of wisdom." You certainly won't in this book. *John Mood.*

VLBI and Compact Radio Sources
R. Fanti, K. Kellermann, G. Setti, eds.
489 pages, hardcover, $54;
paperback, $24.50
D. Reidel (1984)

Very Long Baseline Interferometry (VLBI) is the technique whereby radio astronomers can combine observations made simultaneously using instruments half-a-world apart to gain extremely high resolution. This resolution enables them to study details in complex objects such as active galactic nuclei, QSOs, and gravitational lenses. This book reprints the professional papers presented at an IAU symposium in Bologna, Italy, in 1983.

Man Discovers the Galaxies
Richard Berendzen, Richard Hart, and Daniel Seeley
228 pages, hardcover, $30; softcover, $10.95
Columbia University Press (1984)

This is a paperback reprint of a book on the history of 20th century astronomy and cosmology which originally appeared in 1976. The paperback includes revisions and a new preface.

Universe
William J. Kaufmann III
594 pages, hardcover, $32.95
W.H. Freeman (1984)

Universe is a 29-chapter college textbook which explains the Sun and Moon, planets, stars, black holes, galaxies, quasars, cosmology, and the fate of the universe. It contains numerous colorful diagrams and guest essays by astronomers David Morrison, Philip Morrison, Margaret Burbidge, Owen Gingerich, J. Richard Gott, and Stephen W. Hawking.

The Milky Way
Ludwig Kuhn
151 pages, hardcover, $31.95
Wiley (1982)

Written by a German astrophysicist and subtitled "The Structure and Development of our Star System," this work investigates the contents and origin of the Milky Way. It also describes how astronomers gather information and draw conclusions in their scientific research.

The Voyages of Columbia
Richard S. Lewis
223 pages, hardcover, $24.95
Columbia University Press (1984)

The Voyages of Columbia focuses on the development, testing, and successful deployment of America's first space shuttle.

Sternbilder
Argyris Sfountouris
111 pages, hardcover, 38 Swiss Francs (about $15)
Ex Libris (1984)
[Publisher's address: Ex Libris AG, Postfach, 8023 Zurich, Switzerland]

Subtitled (in translation) "Views into the Night Sky," this German language book combines a simple introduction to star-watching with about 70 color photos of star trails. The photos are annotated with translucent overlays that identify the stars, connect main patterns, and mark such objects as prominent nebulae, clusters, and galaxies.

A Historical Catalogue of Scientists and Scientific Books
Robert Mortimer Gascoigne
1177 pages, hardcover, $150.00
Garland Publishing (1984)

Gascoigne's book is a bibliography that starts in antiquity and runs through the year 1900. He lists scientists (arranged by known birthdate), the works they published, and which editions of their works are available. Astronomy and the other sciences aren't listed separately until the 18th and 19th centuries, although many earlier astronomical works are mentioned together in a general listing. The book contains 15,918 entries and covers more than 13,000 scientists.

Theoretical Concepts in Astrophysics
Malcolm S. Longair
366 pages, hardcover, $49.50; paperback, $14.95
Cambridge University Press (1984)

While creating a course for physics students in their last year of undergraduate study, Longair developed seven case studies in theoretical reasoning. He wanted to get away from traditional teaching methods and help students feel what it is like "doing physics and theoretical physics when the results *really* matter — when your reputation as a scientist hangs on being able to do physics correctly." Three of the case studies involve astrophysics: quanta, special relativity, and general relativity and cosmology.

1,800X
BRANDON®
APOCHROMAT

NEW PRODUCT

Exotic 6-element multicoated lens system allows undreamed of high magnification far in excess of text book theory!

Sensationalism? No! Please read the following letter from our Don V. Yeier to noted A.L.P.O. observer Rodger W. Gordon, written early December, 1984:

Dear Rodger,

As you know, I've been working with apochromatic refractor designs for several years and finally found a lens recipe that didn't cost megabucks to make. Refractive indices, radii, thicknesses were further refined by computer to 80mm x 500mm.

Well, I just got the first O.G. test set made up, mounted, baffled and collimated. An NBS test chart was secured at 250 ft. and flawless, colorfree images were observed to 150x (8mm Brandon and 2.4x Dakin Barlow).

I then located the Dakin in front of the 90° prism calibrated at 5x and again perfect resolution all the way to 312x. Next I added another Dakin 2.4x back on top of the prism. So help me, I stood there in amazement using the 16, 12 and 8mm Brandons up to 750x. Rodger — no color whatsoever and still a razor sharp flat image to the extreme edge of field!

Then — I know this is crazy — I put ***another*** *2.4x Dakin inside the one atop the prism. I'm up to an effective 14,400mm focal length. The 16mm Brandon is still perfect. The 12mm is also perfect! I'm at 1,200x and can't break down the image.*

I fumble and nearly drop the 8mm Brandon. It can't be, but it is! I've got ***sharp, color free test lines at 1,800x!*** *I'm hysterical with ecstacy! This is unheard of! What a lens, what a fantastic set of glass! With those 3 Barlows, the f/6.25 triplet is now f/180, a focal length of over 47 ft.*

Rodger, I've been telescoping all my life ever since my folks bought me a 3" Skyscope at age seven, and have never experienced anything like this. Were this fast f/6.25 system an achromat, we'd be in big trouble at 180x. This animal exceeded that by ***ten times*** *and still sharp, no color.*

I'm still in shock and can't wait until you and your weekend observing group can see this apochromat for yourselves.

Best regards,
Don V. Yeier

The 3" BRANDON Apochromat is now available for immediate delivery with new 70° Wide Angle 20mm BRANDON eyepiece and built-in DAKIN Barlow providing 25x and 60x. Precision rack and pinion plus 1¼" star diagonal and tripod adapter included. Weight 3½ lbs.

Introductory price — $395.⁰⁰ ppd.

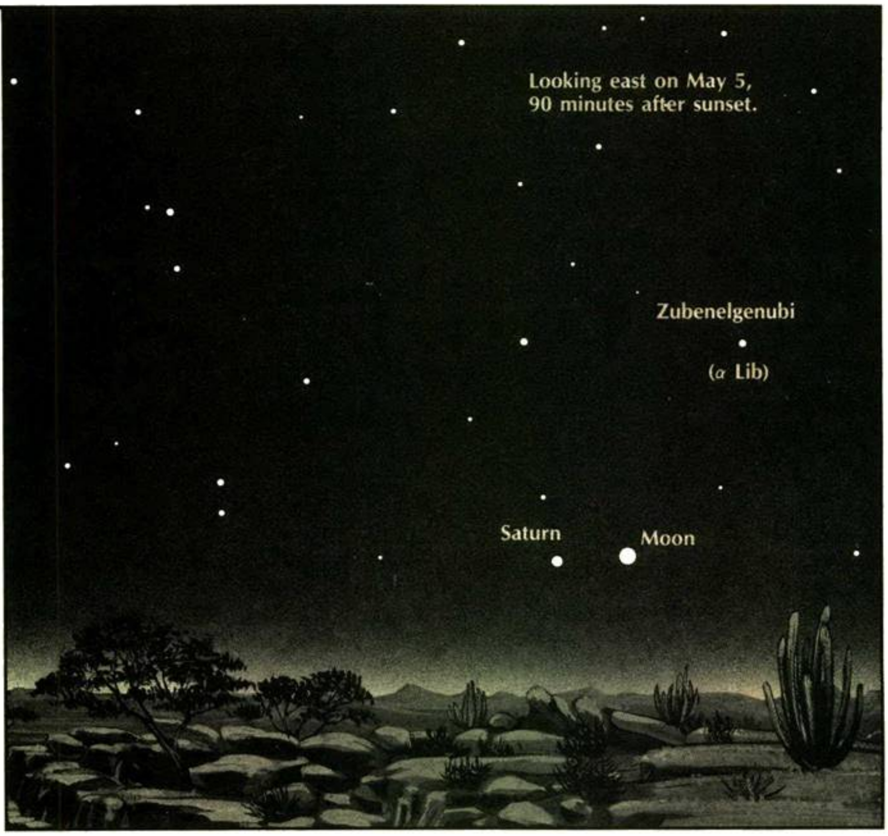
With superior altazimuth mount, slow motion both axes, elevating tripod — $495.⁰⁰.

DAKIN Barlow for 144x and 240x — $65.⁰⁰. C.O.D. orders accepted. Overseas add 10% Air Delivery. NYS residents add 7% sales tax.

VERNONscope & Co.
5 Ithaca Rd., Candor, NY 13743
Phone 607-659-7000

Saturn Comes to Opposition

by Fred Schaaf



The Wanderers

Undoubtedly the most interesting planet this month is **Saturn**, which rises about an hour after sunset as the month opens. Splendid Saturn comes to opposition brighter than it has been for many years and, by wonderful coincidence, also passes spectacularly close to two faint naked-eye stars.

Saturn is heading toward the far point of its orbit (aphelion is in 1988), but for the next few years this has little effect on the planet's brightness. The reason is the increasing tilt of Saturn's icy rings. The rings reflect more sunlight to Earth and therefore make the planet distinctly brighter. Saturn reaches opposition on May 15 and is brightest the day after, when its magnitude reaches about 0. Even more interesting are the planet's two very close conjunctions this month.

On the very day when Saturn is brightest, it floats 8 arc-minutes north of 5.6 magnitude Zeta Librae. This event is upstaged a week later when, at 7h UT on the 23rd, Saturn moves 55 arc-seconds north of 5.9 magnitude 34 Librae. You'll need binoculars or a telescope to see the close approach, but try spotting these faint stars with the naked eye a week later.

Now receding from Earth, bright **Venus** achieves greatest morning brilliancy on May 9 and is slightly fainter than in February when it was in the evening sky. Even though Venus moves south of the ecliptic on May 12, its increasing elongation from the Sun keeps improving its visibility. On the other hand, the ecliptic's shallow angle to the horizon in May mornings is unfavorable enough (from latitude 40° north) to turn the planet's 40° elongation from the Sun into a mere 20° elevation above the horizon. All month, the planet rises about two hours before the Sun, near the start of astronomical twilight (when the Sun is 18° below the horizon). Venus won't escape from twilight until summer.

For information on viewing the Moon, planets, and deep-sky objects with telescopes, see **The Backyard Astronomer**.

There are two eclipses this month, but most readers will not see them. On May 4, the **Moon** plunges into the Earth's umbra; mid-eclipse occurs at 19h56m UT. Observers in Europe, Asia, and Australia will observe at least part of this total lunar eclipse. May's other eclipse — a partial eclipse of the Sun on May 19 — is visible only in parts of Alaska, northern Canada, Greenland, and Iceland.

Several hours before Venus rises, but still after midnight, **Jupiter** enters the sky. Now brighter than magnitude −2, Jupiter slows greatly as it approaches the dim star Iota Capricorni located atop of the saddle shape of Capricornus. Another giant planet is already high in the south as Jupiter rises — **Uranus**, shining at magnitude 5.5. Since this planet's opposition next month occurs near Full Moon, you should try finding Uranus now in southeastern Ophiuchus (you'll need binoculars). For more on this blue-green world, see The Backyard Astronomer.

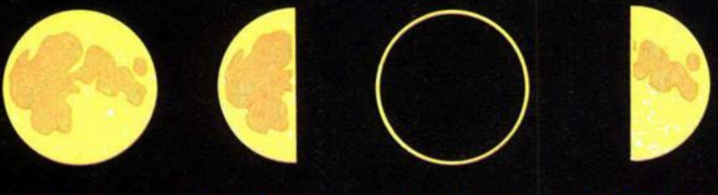
Tiny **Mercury** reaches its greatest morning elongation on May 1 when its separation from the Sun is 26.9°, which is its largest this year. But for observers at mid-northern latitudes, this is the second *worst* of Mercury's seven apparitions in 1985 — the planet is only 10° above the horizon at sunrise. As with Venus, Mercury's poor May showing results from the shallow angle between ecliptic and horizon. In the southern hemisphere, however, the ecliptic is steeply angled to the horizon, and Mercury will be readily visible. The planet won't reach superior conjunction — when it is behind the Sun as seen from Earth — until early June.

In May, **Mars** enters the last days of its current apparition. Around May 10 and 11, look for this almost second-magnitude planet about 6° north of brighter Aldebaran. The pair is then only about 20° south of the Sun in the western sky.

The last pre-Halley occurrence of the **Eta Aquarid meteor shower** is washed out by a Full Moon this month. Still, the shower ought to be monitored for unusual activity. It consists of particles from Halley's Comet and peaks on May 4/5, when up to 20 meteors per hour might be seen from a dark location. Try looking on May 8, when we are nearest Comet Halley's orbit. Next year, a New Moon occurs on this date and there is the possibility of a great meteor display as the shower occurs just a few weeks after Halley crosses the plane of Earth's orbit. But this month, the comet — far below naked-eye and telescopic visibility — becomes lost in evening twilight as it

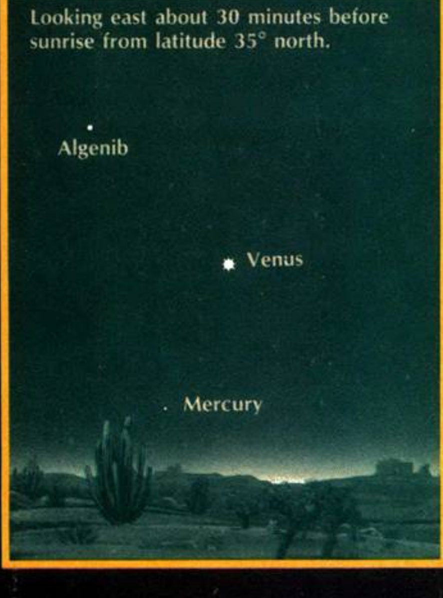
The stars of Draco and Lyra rise over a silhouetted butte in Monument Valley, Utah. Mack Frost used a 24mm lens set at f/22 and 400-speed film to take this photo. He *first* took a *short* exposure to get untrailed stars, covered the lens, waited a few minutes, then uncovered the lens and exposed for 3 hours.

May's Night Sky

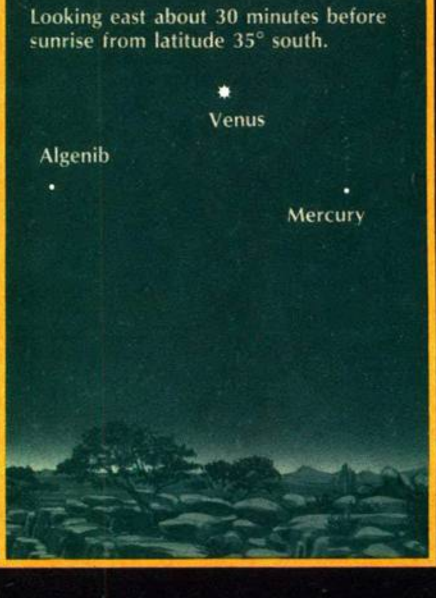


Full Moon	Last Quarter	New Moon	First Quarter
May 4	May 11	May 19	May 27
3:52 p.m. EDT	1:34 p.m. EDT	5:41 p.m. EDT	8:41 a.m. EDT

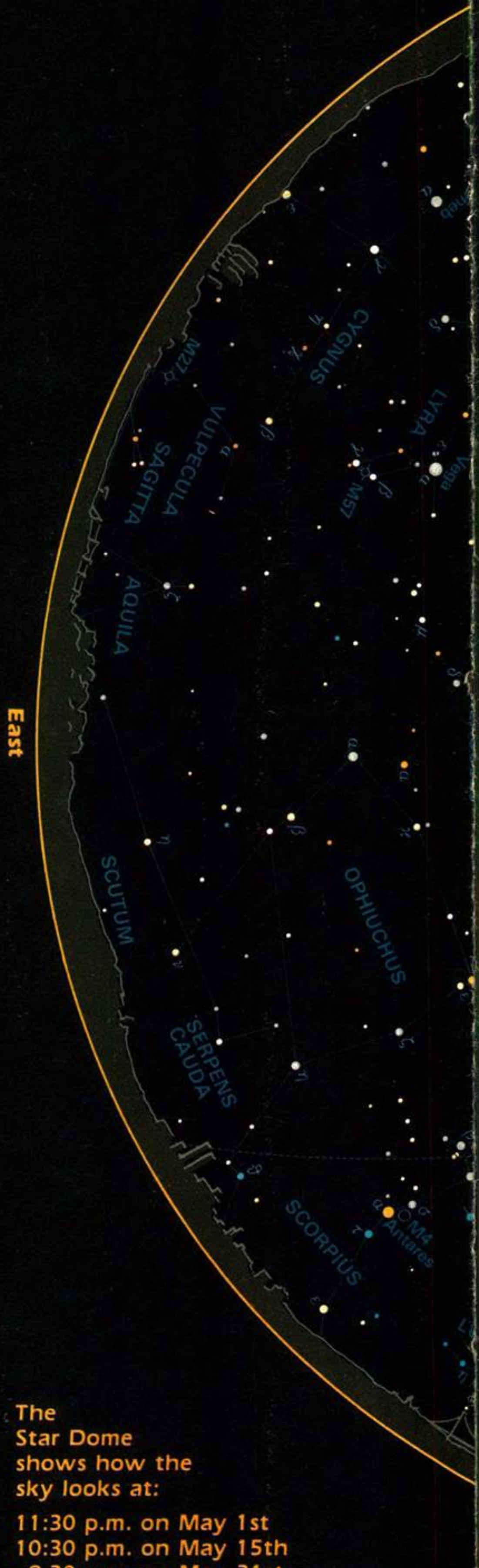
1st	Mercury is at greatest morning elongation, 26.9° from Sun. For observers located in the northern hemisphere, this is the planet's worst apparition for the year. For those in the southern hemisphere, however, Mercury will be rather easy to find. Compare the maps below.
4th	Moon reaches perigee at 1:23 a.m. EDT and is then 222,216 miles away.
5th	The Moon, one day past Full, passes 3° south of Saturn (see illustration on page 42). Also tonight, the Eta Aquarid meteors reach their peak. On a dark night, you can expect to see about 20 meteors an hour, but this year the bright Moon will wash out all but the brightest trails. Still, the shower may be unusually active due to the nearness of the parent comet — Halley's.
8th	Venus reaches its greatest morning brilliancy — magnitude −4.22.
11th	Tonight, try finding ruddy Mars low in the west about 30 minutes after sunset. Compare its color to orange-tinged Aldebaran (α Tauri), which lies about 6° south of the Red Planet.
15th	Saturn is at opposition, which means two things. First, Saturn crosses the meridian at midnight and is now up all night long. Second, the planet is at its nearest to us — 829 million miles away.
16th	Moon reaches apogee at 7:50 p.m. EDT. It will then lie 252,341 miles away.



Looking east about 30 minutes before sunrise from latitude 35° north.

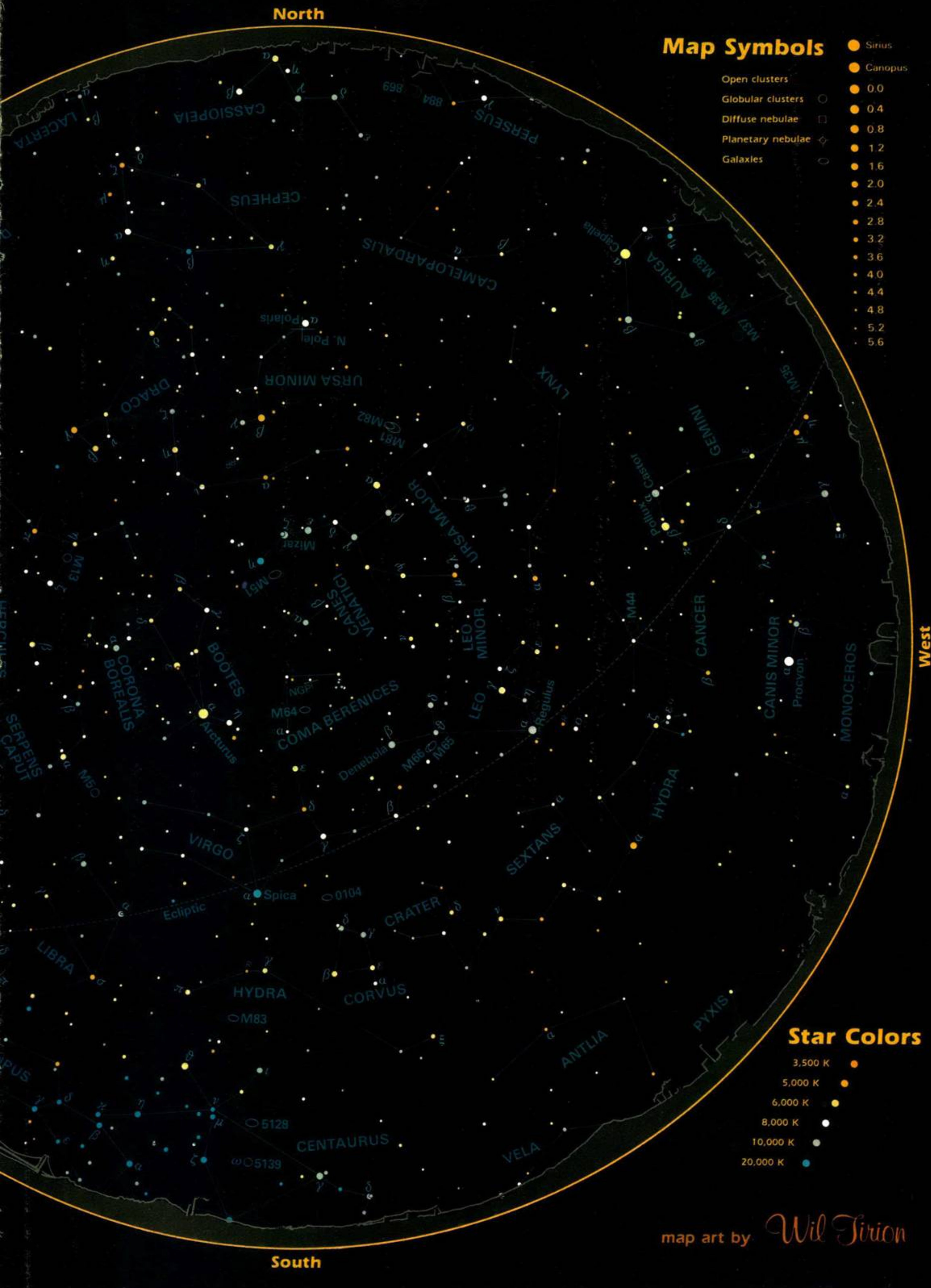


Looking east about 30 minutes before sunrise from latitude 35° south.

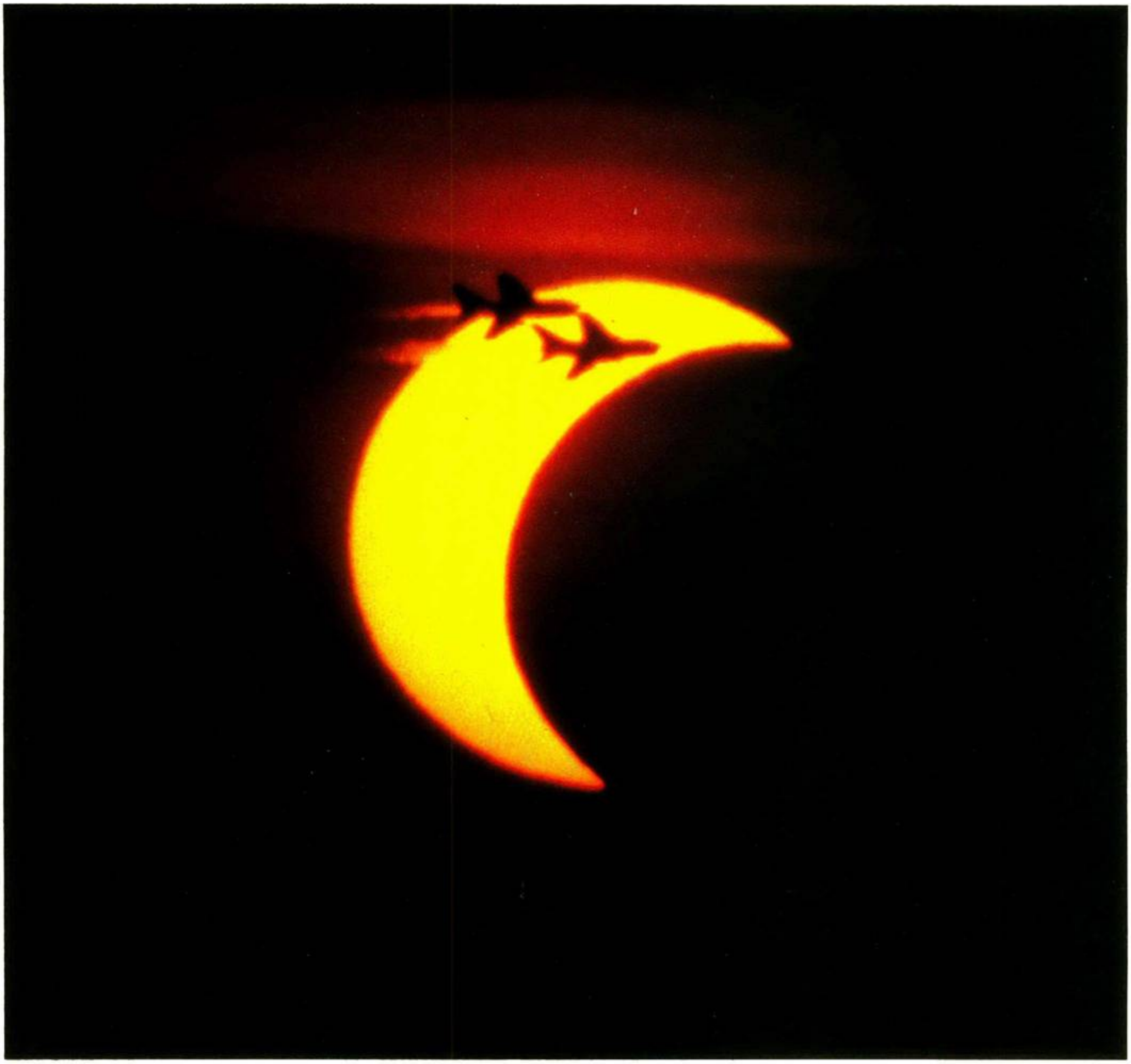


The Star Dome shows how the sky looks at:

11:30 p.m. on May 1st
10:30 p.m. on May 15th
9:30 p.m. on May 31st


North
South
West
Map Symbols
Sirius
Canopus
0.0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
4.0
4.4
4.8
5.2
5.6
Open clusters
Globular clusters
Diffuse nebulae
Planetary nebulae
Galaxies
Star Colors
3,500 K
5,000 K
6,000 K
8,000 K
10,000 K
20,000 K
LACERTA
CASSIOPEIA
PERSEUS
869
884
CEPHEUS
CAMELOPARDALIS
Capella
AURIGA
M38
M36
M37
M35
Polaris
N. Pole
URSA MINOR
DRACO
LYNX
GEMINI
M82
M81
Castor
Pollux
URSA MAJOR
Mizar
M13
M51
CANES VENATICI
LEO MINOR
M44
CANCER
CANIS MINOR
Procyon
MONOCEROS
HERCULES
CORONA BOREALIS
BOOTES
Arcturus
NGP
M64
COMA BERENICES
LEO
Regulus
SERPENS CAPUT
M5
Denebola
M66
M65
HYDRA
SEXTANS
VIRGO
Spica
0104
Ecliptic
CRATER
LIBRA
HYDRA
CORVUS
M83
PYXIS
ANTLIA
LUPUS
5128
CENTAURUS
ω 5139
VELA

map art by *Wil Tirion*



During the partial solar eclipse in May 1984, Robert Bunge on the aircraft carrier U.S.S. America caught two Corsairs as they crossed over the Sun's disk. Bunge used a 500mm lens set at f/16, an exposure of $\frac{1}{2000}$ of a second, and Kodachrome 25 for this shot.

moves eastward in Taurus just above the Taurus-Orion border.

The Starry Sky

On May evenings, the **Big Dipper** is high in the north for most readers. While those with telescopes scrutinize the Virgo and Coma clusters of galaxies, there is an arc of bright stars to trace with the unaided eye. Interestingly, this great arc forms a semicircle that runs from the Big Dipper (on the northern end) to Arcturus, Spica, and the stars of Corvus. The densest concentration of galaxies is midway around the semicircle.

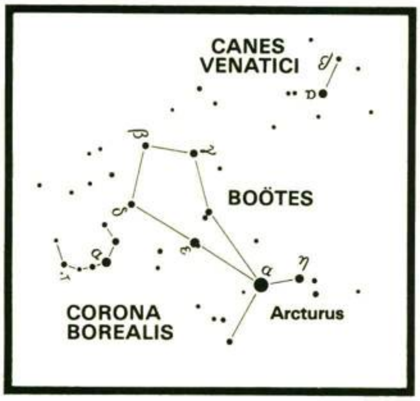
What's a good mnemonic device for getting the names of the Big Dipper's stars in their correct order? One problem is that six of the eight names (counting Mizar's companion, Alcor) begin with either an "A" or an "M". The famous Pointers, which lead to Polaris, the North Star, are Dubhe and Merak. Even if you cannot see Alcor with the naked eye, you should be able to remember that Mizar marks the bend in the handle. The Greek letter designations of these stars do follow in alphabetical order, starting from northernmost Dubhe (α), working around the bottom of the bowl and out to the end of the handle.

Follow the handle's curve onward to brilliant Arcturus — the "arc to Arcturus" — on our semicircle. So much attention is given to this bright- orange star that its constellation — **Bootes** the Herdsman — is often overlooked. The second brightest star in the constellation is Epsilon Bootis or Izar. This star was found to be a double in 1829 by F.G.W. Struve, who was so impressed with the orange and blue pair that he named it Pulcherrima — "the most beautiful." A 4-inch or larger telescope is generally required for a decent separation, but with the naked eye you may note the other nearby (but faint) stars of the Herdsman's waist, Sigma and Rho Bootis.

Next, leap from 2.4 magnitude Izar to the next star in the region of comparable brightness, second-magnitude Gemma. Gemma is the chief luminary of a separate constellation, Corona Borealis (the Northern Crown) — a pattern that may have represented the sickle of the Herdsman in ancient times. We'll *examine Corona next month.*

Canes Venatici (the Hunting Dogs) is a rather inconspicuous constellation north of Bootes, tucked under the Dipper's handle. Its two principal stars are Cor Caroli and Chara; the former shines at magnitude 2.9 and a small telescope splits it into a pleasing double.

Canes Venatici is a useful reference point: a line from the end of the Big Dipper's handle through Canes to Leo's "tail" star (Denebola) intersects two superb dark-sky objects. Just a few degrees from the Dipper's handle is the Whirlpool Galaxy, M-51, which can be spotted in 7x50 binoculars under exceptional skies. Midway between Canes Venatici's duo of Cor Caroli and Chara and Leo's Denebola lies the dim but intricate net of stars called the **Coma star cluster**. This is the second closest of all star clusters and therefore extends over several degrees — it's the most noticeable naked-eye feature of the constellation Coma Berenices (Berenice's Hair). The closest cluster of stars is the Ursa Major Moving Group — you see some of its bright members each time you look at the Big Dipper.

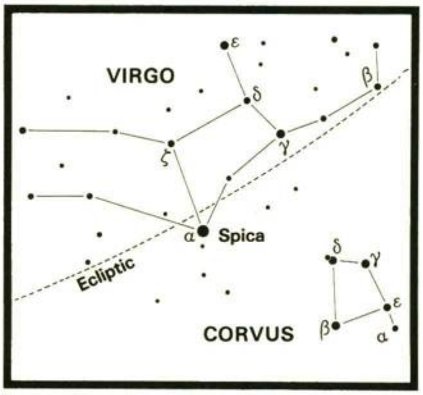


Due south of the Coma cluster is the finest region for telescopic galaxy hunting. The faint patterns which lie between the Big Dipper's handle high in the north and the skewed square of Corvus the Crow midway up in the south are: Canes Venatici, Coma Berenices, and Virgo the Virgin. The constellation of Virgo is practically as large as our semicircle, and several times larger than the Big Dipper! Virgo's brightest star — **Spica** — is the link in our semicircle between Arcturus and Corvus. Spica, which means "ear of wheat," marks the wheat the Virgin holds at her hip and shines at 1.0 magnitude — 100 times brighter than the faintest stars visible on the clearest and darkest nights.

Although most first-magnitude stars are relatively close, some are actually far more distant than others. In the winter sky, for instance, Orion's Rigel is probably 100 times farther off than bright Sirius; in summer's sky, Deneb in Cygnus is 100 times more distant than Altair in Aquila. Of spring's three first-magnitude stars, Arcturus is only about 37 light-years away; it is 115 times brighter than our Sun. Regulus, at a distance of 85 light-years, shines with the luminosity of 160 Suns. Spica, however, is thought to be 275 light-years away — and 2,300 times more luminous than the Sun!

To either side of Spica stretches the constellation Virgo. Her head is dreamy with clouds of galaxies and one of the moderately bright stars in her bosom, Gamma Virginis, or Porrima, is another of spring's famous telescopic doubles. The September equinox point lies in Virgo; the constellation also covers over three hours of right ascension along the celestial equator.

We dealt with Corvus, the south end of our spring semicircle, in previous months. But in this year of Comet Halley's approach there is special reason for northerners to seek out a certain object below Corvus. You can find it by extending a line southward from Spica, east of Corvus, and right through the stars Gamma Hydrae and Iota Centauri. The object is third-magnitude **Omega Centauri**, the brightest of all globular clusters (see May's Night Sky). A young Edmond Halley discovered this object while on the island of St. Helena in the South Atlantic (where, more than a century later, Napoleon was sent to his final exile). In April 1986, Halley's Comet will pass just a few degrees from Omega Centauri. The comet's head will be about the same size as the cluster but brighter.



Skylore

Canes Venatici, the Hunting Dogs usually associated with Bootes the Herdsman, is not an ancient figure like Bootes. Ptolemy included its stars with those of Ursa Major. The inventor of Canes Venatici was Johannes Hewelcke (1611-1687), better known as Hevelius. This fascinating astronomer had an important encounter with Edmond Halley and is linked to him in several ways.

Both Halley and Hevelius apparently had a part in establishing the nomenclature of this constellation. The name of the brightest star in Canes Venatici is Cor Caroli, which means "Charles's Heart." Whereas Hevelius formed and named the pattern as a whole, Halley is usually credited with popularizing the name Cor Caroli. According to R.H. Allen in *Star Names: Their Lore and Meaning,* Halley supported this designation at the suggestion of the court physician, Sir Charles Scarborough, who said that the star had shone with special brilliancy on the eve of Charles II's return to London on May 29, 1660 (at the end of Cromwell's rule). Halley actually set the star apart as a distinct figure (it can sometimes be seen marking a heart with a crown on old star maps) in 1726 when he was Astronomer Royal.

That Halley should choose to honor Charles II so many years later is not surprising: this was the monarch who helped the young Halley take a trip to St. Helena, where he performed his first important scientific study — creating a catalogue of southern stars. Upon return, young Halley secured his master's degree by proposing a new constellation, Robur Carolinum, meaning Charles's Oak, "in commemoration of the Royal Oak of his patron, Charles II, in which the king had lain hidden after his defeat by Cromwell in the battle of Worcester, on the third of September 1651." But Halley's new constellation was unsuccessful. In this respect, Halley differed from Hevelius. In addition to Canes Venatici, Hevelius created six other constellations: Lacerta, Leo Minor, Lynx, Scutum, Sextans, and Vulpecula.

At least Halley succeeded in establishing Cor Caroli — or did he? Robert Burnham, Jr. reports that the original name of the star was "Cor Caroli Regis Martyris," in honor of the executed King Charles I. The name probably was not in wide use, he says, until the restoration of the British monarchy under Charles II. If the name was in wide use during Halley's youth, then perhaps his support of it in old age did little to establish it.

Anyone who wants to learn more about the relationship between old Hevelius and young Halley should consult Colin Ronan's book *Edmond Halley: Genius in Eclipse*. This biography, written almost 20 years ago, is a book any prospective watcher of Halley's Comet will enjoy reading.

There are several other interesting star names in Canes Venatici. The constellation's second brightest star, Chara (the "ch" is pronounced as a "k"), has a name which means "dear" in Latin. Cor Caroli and Chara form one of the two Hunting Dogs, whose name is also Chara. Fainter stars to the north form the second dog, Asterion, meaning "starry" in Greek.

One more star in Canes Venatici has received a proper name — though it is never brighter than about magnitude 4.8. Today it is called Y Canum Venaticorum, but the 19th century astronomer Father Angelo Secchi called it "La Superba." The title refers to Y Canum's unusual spectrum; a look in binoculars reveals it to be one of the reddest stars in the heavens. La Superba is one of the carbon stars — very cool, very red members of the spectral class N.

LIMITED TIME OFFER
SPACE SHUTTLE

VIDEOCASSETTES
Official
NASA Full Color-Sound
Films at Great Savings

1. Apollo 8 22 min:
   Borman Orbits Moon $29.95
2. Apollo 11 29 min:
   1st Moon Landing $29.95
3. Apollo 15 28 min:
   "Rover" on Moon $29.95
4. Apollo 17 28 min:
   Great Earth Photos $29.95

"MAY SPECIAL"

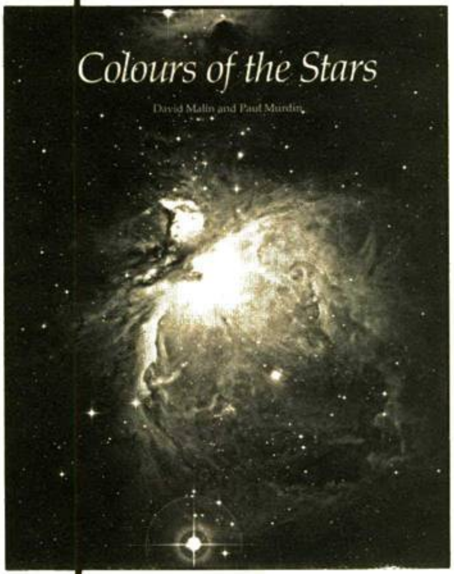
Save $70.00

All 4 films on one videocassette
only $49.95 + $3.00 Shipping/handling
Offer Ends June 30, 1985

Order Toll Free 800-437-0800
VISA Calif. res. 800-437-0888
MasterCard **Hayes & Nolly Productions**
3000 Alamo Drive, Suite 206
Vacaville, CA 95688

Unconditional 30 day money back guarantee

Colours of the Stars
by David Malin & Paul Murdin



Why does the Orion Nebula look green in your telescope's eyepiece, but photograph bright red? What makes Betelgeuse and Antares look red? Spica look white? And Rigel blue-white? *Colours of the Stars* is a fascinating look at why stars and other celestial objects have color — and what color tells us about them. It also delves into the subjective realm of how we perceive colors — and why our eyes tell us one thing where photographic films show another. Anyone who's ever thrilled at seeing the soft glow of the Trifid Nebula — or delighted in the contrasting colors of Albireo — should not miss this beautifully illustrated book!

$28.50

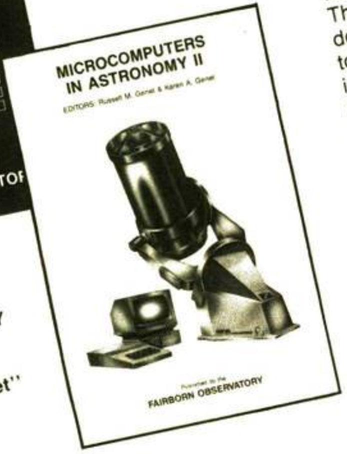
198 pages, hardcover

To order, use the AstroMedia order form bound into this issue, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

COMPUTERIZE YOUR TELESCOPE!

FAIRBORN OBSERVATORY STATE-OF-THE-ART BOOKS ON MICROCOMPUTER APPLICATIONS IN ASTRONOMY

MICROCOMPUTERS IN ASTRONOMY
EDITOR: Russell M. Genet
FAIRBORN OBSERVATOR


MICROCOMPUTERS IN ASTRONOMY II
EDITORS: Russell M. Genet & Karen A. Genet
Published by the FAIRBORN OBSERVATORY

Microcomputers in Astronomy, ed. by Russell M. Genet. Thirty papers presented at the Fourth Fairborn Symposium detail the present state-of-the-art in applying microcomputers to automatic telescope control. An absolute must for everyone interested in controlling telescopes or photoelectric photometers by computer. 253 pages, paperback, **please specify Volume 1,** (was $23.95). **$14.95**

NEW

Microcomputers in Astronomy II, ed. by Russell M. Genet and Karen A. Genet. Learn how amateur astronomers use microcomputers to control telescopes from 8″ to 41″ aperture — with computers from Commodore, Apple, and Sinclair. Read about computer star maps, databases, and automated telescopes. Twenty-three papers from the Fifth Fairborn Symposium will keep you up-to-date. 224 pages, paperback, (published at $23.95). **$14.95** **please specify Volume 2,** —

— Combine Your Computer and Your Telescope —

To order, use the AstroMedia order form bound into this magazine, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

SAVE MORE!
Order both volumes for ONLY
$24.95
Specify "Microcomputers Set"

Meade & Celestron
LUMICON Carries a full line of telescopes & accessories. Fast Delivery, competitive prices. Both Catalogues $3.

LUMICON FOR HIGH PERFORMANCE

ASTROPHOTO OF THE MONTH

The "Black-Eye" Galaxy M-64 in Coma Berenices. The dark "eye" is visible at higher power. Photo by Ron Potter using LUMICON hypered 2415 film, 2 hour exposure, C-14 at f/11.

LUMICON® FILTERS STOP LIGHT POLLUTION

The **LUMICON DEEP-SKY Filter**™ improves both visual and photographic contrast on all deep-sky objects, including galaxies. The **LUMICON UHC Filter**™ is for viewing only and yields the highest contrast for planetary and emission nebulae of any filter available today.

Filter Type	UHC	Deep-Sky
For 0.965" eyepieces	—	$49.95
For 1¼" eyepieces	$79.50	$59.50
48mm for 2" eyepieces	$129.50	$99.50
For 2" eyepieces & photography		$99.50

Set, 1¼" UHC & Deep-Sky Filters . . $125.00
Set, 48mm UHC & Deep-Sky Filters . $199.50
Selected premium filters . . . . . . add $20 ea.
H-Beta Filter, 1¼" . . $79 48mm . . $129

H-ALPHA PASS FILTER

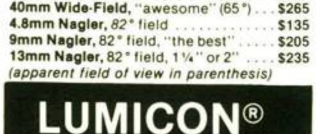
Yields spectacular contrast gains in B&W photography with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	H-Alpha	(MV)
46, 48, 49mm	$29.95	$25.00
52, 55, 58, 62mm	$39.95	$29.95
67, 72, 77mm	$46.95	$39.95
82mm	$49.95	

Hypered 2415 film, 36 exp . . . $9.95 . . . 3/$27

TELE VUE™ EYEPIECES USE THE BEST!!

ALL IN STOCK



Plossl, Wide-Field, Nagler Eyepieces

7.4, 10.4, 13, 17, 21, 26mm Plossl(50°)	$74
2½ X Tele Vue Barlow Lens	$74
32mm Plossl, widest true field in 1¼"	$88
55mm 2" Plossl, widest possible field	$168
19mm Wide-Field, 1¼" eyepiece (65°)	$119
24mm Wide-Field, "superb" (65°)	$135
32mm Wide-Field, 2" eyepiece (65°)	$205
40mm Wide-Field, "awesome" (65°)	$265
4.8mm Nagler, *82°* field	$135
9mm Nagler, 82° field, "the best"	$205
13mm Nagler, 82° field, 1¼" or 2"	$235

(apparent field of view in parenthesis)

LUMICON®
2111 Research Drive #5A, Livermore, CA 94550
For phone orders please call (415) 447-9570
LUMICON Products catalogue $2.
Foreign orders add 6% ($20 for HYPER-KITS)
California Residents add 6% tax.
Prices subject to change w/o notice.

NEW! ENHANCED SILVER DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 3.1" enhanced silver diagonal mirrors & 2" star diagonal.
The new LUMICON diagonal mirrors have a special enhanced silver coating with a protective overcoating for long life. Visible reflectivity is 98-99% compared to 86-89% for standard aluminum coated mirrors. The extra 10-12% transmission is like adding an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

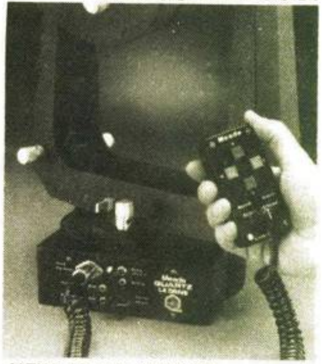
1.32" . **$29.95** 1.52" . **$34.50** 1.83" . **$39.50**
2.14" . **$47.50** 2.60" . **$59.50** 3.10" . **$79.50**
4.25 . **$129.50**

ENHANCED SILVER STAR DIAGONAL

90° star diagonals with above enhanced silver mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror) **$79.50**
2" (1.83" mirror)(see photo above) . . **$119.50**

Meade TELESCOPES AT LUMICON



NEW! Meade 2080LX3

The 2080LX3 8"f/10 telescope has built-in ultra precise quartz LX Drive System. Includes 8x50mm illuminated polar viewfinder, multi-coated diagonal, piggyback mount, special coatings, padded carrying case, 20mm & 7mm Research Series, eyepieces & other standard accessories. Shipping added, f.o.b. Livermore CA.

Meade 2045 4"f/10 w/ table tripod	$595
Meade 2080/LX3 w/ wedge & tripod	$1695
Multi-coatings/silvered optics	add $149
Meade 2080/LX2 w/ special coatings, precision LX drive, 8X50mm viewfinder, 20mm (100X) & 7mm(286X) Research Series eyepieces, wedge and tripod. ($2450 list)	$1485
Meade 2120LX3 (10") w/wedge & tripd	$2695
Multi-coated/silvered optics for 2120	add $195

OPTIONS BOOST PERFORMANCE

Multi-coated/silvered optics group adds 18% transmission (2080 LX2, LX3)	add $149
Model 36 dual-axis control box, LX3 only	$99
Model 38 declination motor w/clutch	$99
Dew shield & access shelf ($130 list)	add $89
Model 46L dual-axis drive corrector & elec. declination for photography (2080LX2)	$298
LUMICON EASY-GUIDER™ and rich-field viewer combination (f/6.2 operation)	add $198
LUMICON 1¼" Deep-Sky Filter, prem.	$79

Meade Model 628 6"f/8 Newtonian Telescope

Meade 6" & 8" Newtonian Telescopes offer the best value today for serious amateurs. The **Model 628** yields the best Lunar/planetary viewing. The **Model 826** collects 78% more light and is thus better for deep-sky viewing and photography. These telescopes include a motor drive, 6X30mm view finder, 1¼" rack & pinion focuser, 25mm (48x) and 9mm (135x) eyepieces, setting circles, and a sturdy equatorial mount with pier and legs. Shipping added.

Model 628, 6"f/8 with motor drive	$785
Model 645, 6"f/5 Rich-Field Telescope	$795
Model 826, 8"f/6 with motor drive	$890
Substitute #680 2" focuser	add $48
Substitute 8X50mm view finder	add $48
Dust covers (2) 6" . . . . . $15 8"	$20
Accessory shelf for eyepieces etc	$32
Model 47M dual-axis drive corrector and electric declination for photography ($360 list)	$330
LUMICON 2" EASY-GUIDER for perfect astrophotos (requires #680 focuser)	add $149
1¼" LUMICON UHC Filter, prem.	add $89

DEEP-SKY ASTROPHOTOGRAPHY

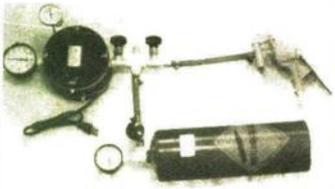
FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15X film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

†Patent Pending

MODEL 100 HYPER-KIT for 35mm film, rolled-up. *Takes longer,* but it easy to use. Not recommended for 2415 . . . . **$225.00**

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$275.00**



MODEL 600 HYPER-KIT [See Photo] Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$299.50**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller . . . **$525.00**

Temperature controller for any HYPER-KIT **$59.50**

Electric Vacuum Pump **$265.00**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER**™ off-axis guiders† have both radial and 360° rotational adjustments for 5X eaiser guide-star selection, use 48mm filters, 360° camera rotation, large prisms fo bright guide-starts. *Specify Camera and Telescope type.*
U.S. Patent # 4,448,500

NEWTONIAN EASY-GUIDER™

Full aperature. Installs in secs. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER **$149.50**
3X Relay Diagonal [See Photo] **$69.50**
Illuminated reticle eyepiece system . **$59.50**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Dynamax-8. Includes 50mm achromatic lens for f/5.8 operation-3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$199.50**

GIANT EASY-GUIDER™

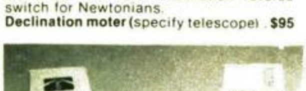
For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$359.50**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER [SAVE $20] . . . . . . **add $79.95**

WHAT DO YOU NEED?

1. **Illuminated reticle eyepiece** **$59.50**
Lumicon 12mm eyepiece system has adjustible L.E.D. illumiation, dual crosslines, battery pack.
2. Cable release for long exposures . **$9.95**

3. **Lumicon Quartz Drive Corrector** . . . **$198**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 40Hz/80Hz variable output controls telescope drive. 60Hz Quartz reference, ± 12V.D.C. Declination control output. Both 110VAC and 12VDC input for home or field use. Declination reverse switch for Newtonians.
Declination moter (specify telescope) . **$95**



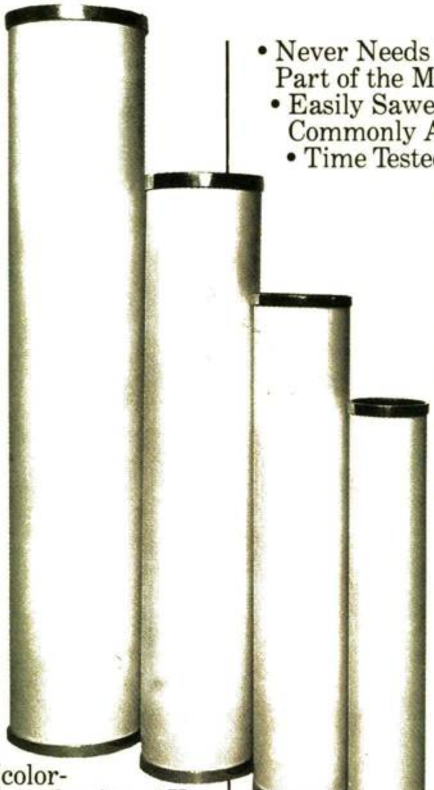
HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography.

Film Type (35mm unless marked)	Exposures	Price
2415, Ultra-fine B&W, red sens	36	$9.95
VR200, fine grain color negs	12	$9.95
Fujichrome 400, "Excellent"	20	$12.95
HR1600, fastest of all, color negs	24	$12.95
5072, color slides from negs	36	$6.95
D-19 B&W Developer	1 gal.	$6.95

PARKS PRODUCTS: THE INTELLIGENT ALTERNATIVE

Offering Astronomical Performance, Quality and Value—Since 1954.



Parks products are carefully crafted and quality-controlled to assure absolute confidence of purchase and performance. Each Parks product is guaranteed to professional standards and comes complete with our 30 years of astronomic and optical design experience behind it.

To order with Visa or Mastercard call toll-free 800-44-PARKS (for *orders* only), in Calif. call 800-43-PARKS. Or send a check or money order (plus 6% for California residents) with a description of the product. We pay shipping and insurance on all merchandise to continental U.S.A., except tubes and equatorial mounts, which are shipped freight collect. All merchandise is returnable within 15 days if you are not 100% pleased.

For more information call us at (805) 522-6722.

PARKS PRT-2 ASTRONOMICAL REFRACTOR

A classic design; brilliant, high contrast images. 700mm focal length with a 60mm coated, fully achromatic (color-corrected) objective. Complete with diagonal prism, 2X Barlow, 20mm and 6mm oculars, built-in finderscope, adjustable wooden tripod with accessory tray, and altitude-azimuth mount with fine slow-motion controls. Reg. $399.00, introductory offer $299.00.

PARKS PRT-46 ASTRONOMICAL EQUATORIAL REFRACTOR

A time-tested, brilliant image optical configuration featuring 910mm focal length, 60mm objective lens. Fully coated, achromatic objective lens. Comes with 4mm, 9mm and 22mm oculars, star diagonal, porro prism, solar projection tray, 2X Barlow, built-in finderscope and sturdy, adjustable wooden tripod with accessory holder. Equatorial mount with right ascension and declination slow-motion controls, counter-weighted for precise balance. Reg. $599.00, introductory offer $399.00.

PARKS WORLD-STANDARD FIBERGLASS TUBES.

Unique and unexcelled in all the world—there are none finer.

- Virtually Indestructible
- Extremely Low Thermal Conductivity for Maximum Optical Performance
- Resists Moisture and Corrosion
- Does Not Chip or Peel
- Exterior is White Smooth Glass-like Finish, and Flat Black Interior
- Never Needs Painting. Their color is an Integral Part of the Manufacturing Process
- Easily Sawed, Drilled or Riveted by Using Commonly Available Tools
- Time Tested and Fully Guaranteed

For 4½″ Mirror	
5″ x 48″	$ 39.00
For 6″ Mirror	
7″ ID x 31″ to 52″	$ 52.00
7″ ID x 53″ to 60″	$ 56.00
Anodized Aluminum end rings/pair	$ 16.00
For 8″ Mirror	
9⅜″ ID x 24″ to 37½″	$ 56.00
9⅜″ ID x 38″ to 55″	$ 68.00
9⅜″ ID x 56″ to 60″	$ 72.00
9⅜″ ID x 61″ to 75″	$ 80.00
Anodized Aluminum end rings/pair	$ 17.00
For 10″ Mirror	
11⅞″ ID x 40″ to 48″	$ 99.00
11⅞″ ID x 49″ to 62″	$116.00
11⅞″ ID x 63″ to 72″	$132.00
Anodized Aluminum end rings/pair	$ 24.00
For 12½″ to 14¼″ Mirror	
15⅞″ ID x 48″ to 59″	$148.00
15⅞″ ID x 60″ to 69″	$160.00
15⅞″ ID x 70″ to 79″	$170.00
15⅞″ ID x 80″ to 100″	$190.00
Anodized Aluminum end rings/pair	$ 28.00
For 16″ Mirror	
18″ ID x 48″ to 60″	$160.00
18″ ID x 61″ to 90″	$240.00
18″ ID x 91″ to 120″	$280.00
Other Sizes Available Upon Request	

PARKS PROFESSIONAL OCULARS

Precision-machined of brass or aluminum, threaded for filters, multi-coated for brilliant performance.

Kellners—quality and value. 1¼″ in 6, 12, 25, 40mm: $30.00 each. 2″ 50 and 60mm: $90.00 each.

Orthoscopics — flat field, excellent brilliance, color correction and resolution. 1¼″ 5, 6, 12.5 and 25mm: $49.00 each.

Erfles — wide 65 degree field, perfect for deep space, comets. 1¼″ in 20 and 32mm: $59.00 each. 2″ in 32mm: $129.00 each.

Plössls — 4-elements, unbelievable performance, eye-relief. 1¼″ in 6, 9, 12.5, 18 and 25mm: $59.00 each. 40mm: $69.00 each.

PARKS ASTROPHOTOGRAPHY ACCESSORIES

Illuminated reticle eyepiece. State-of-the-art guidance system. 12.5mm multicoated orthoscopic eyepiece. Dual cross-hairs, focusable, adjustable brightness, separate on-off switch. Illuminated by LED, powered by mercury cells batteries (incl.). Battery pack is 2¼″ x ¾″ weighs only 2½ oz. $99.00

SEND FOR OUR FREE CATALOG AND PRICE LIST. $5/U.S. for all foreign.

CREDIT CARD ORDERS:
800-44-PARKS (CA. 800-43-PARKS)
INFORMATION: (805) 522-6722.

VISA
MC

PARKS **Optical Company**
270 Easy Street — Dept A5
Simi Valley, CA 93065

How to Use a Polefinder

Equipment Atlas

by
Paul J. Burke

It's an old idea in a new form. It eliminates the biggest bugaboo of the portable telescope. It makes nightly setup quick and accurate. What is it?

We're talking about the built-in polar axis alignment telescope.

Several commercial telescopes now feature this handy observing accessory — a small telescope built right into the polar axis of the equatorial mounting. To use it, you set the dial for the date and time, position Polaris inside a little circle in the reticle, and — bingo! — you have photo-quality polar alignment with a lot less hassle than the old star-drift technique.

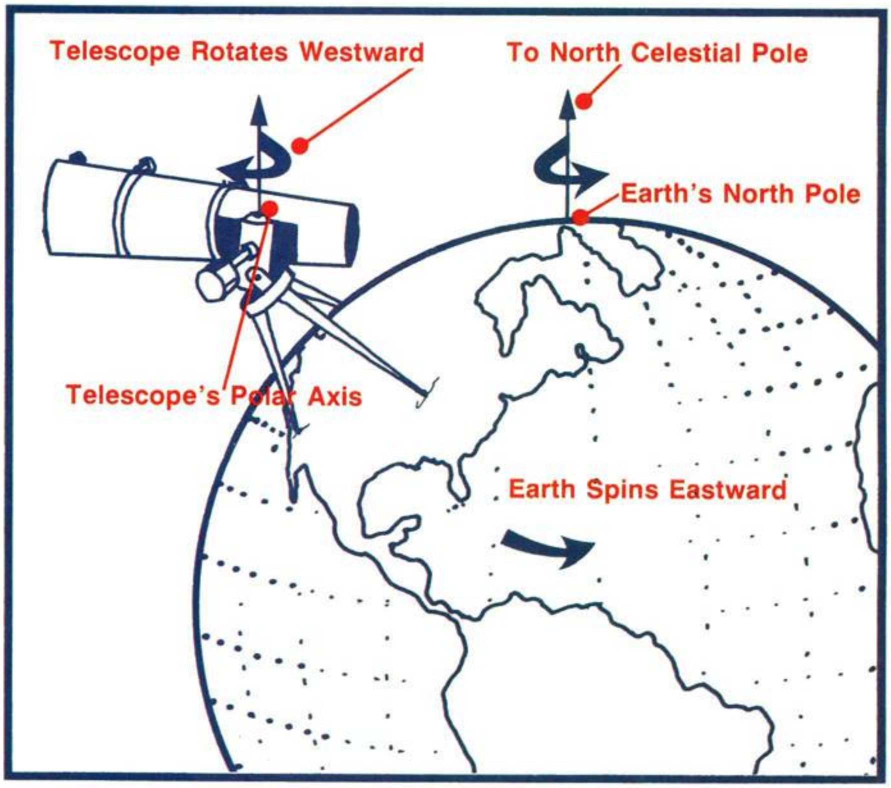
But one thing most polar axis alignment rigs lack is a set of coherent instructions on how to use the device — something gets lost in the translation, so to speak. So let's look at how these polar alignment telescopes work, and see how you can use one for better polar alignment.

As the World Turns . . .

As Earth turns on its axis, the stars revolve around us. Of course, the stars don't actually move, but only appear to do so because the Earth is turning. Most of the stars move westward across the sky, rising in the east and setting in the west. However, stars near the north and south celestial poles circle fixed points called the north and south celestial poles.

The apparent motion of the stars is annoying to telescope users because the motion is magnified by the telescope. If you mount your scope so that it rotates in the direction opposite that of Earth, then you cancel out the motion of the stars and they appear stationary in the eyepiece.

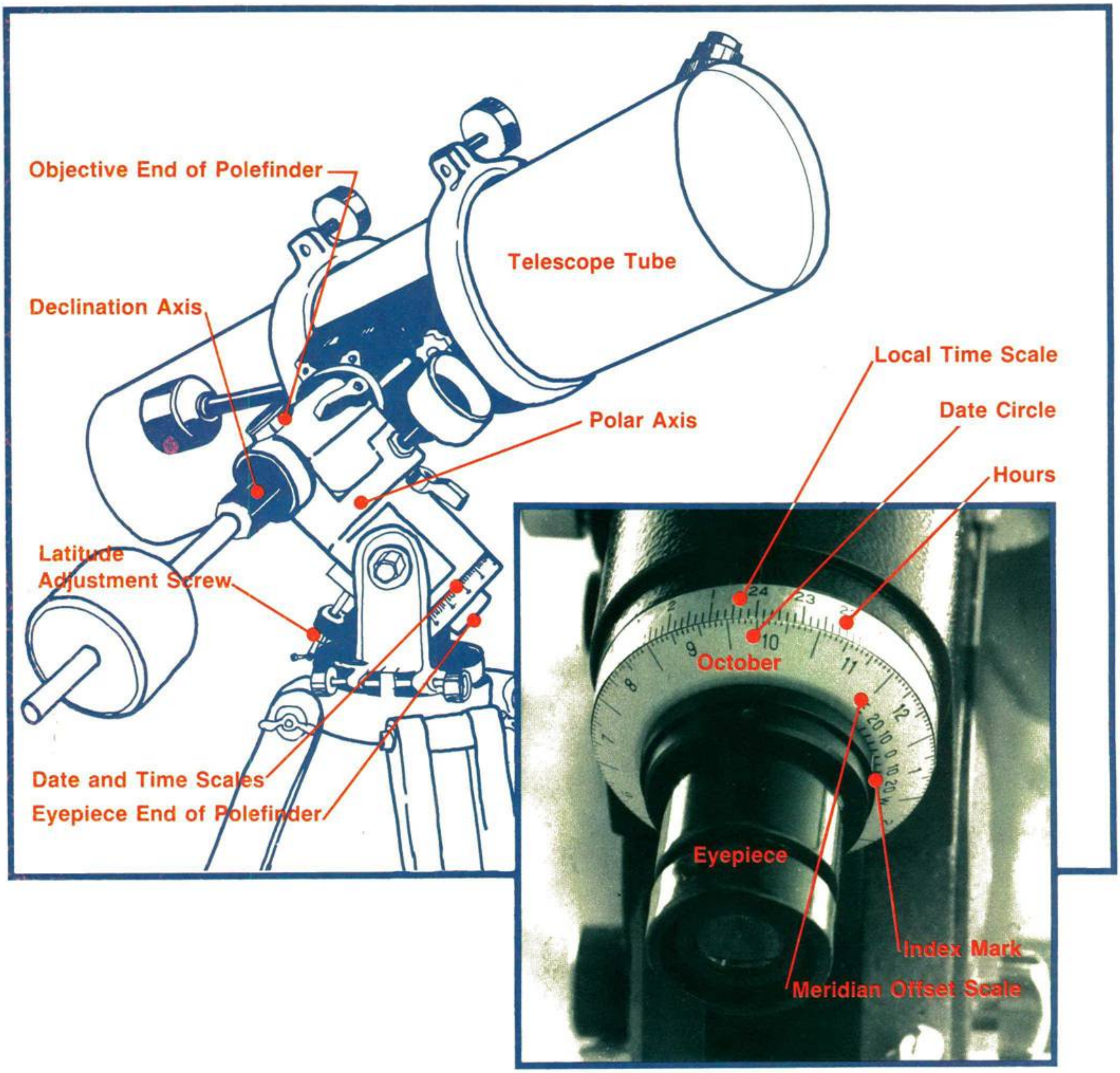
But getting a telescope to rotate in the opposite direction of Earth isn't as easy as it sounds. The motion must not only be at the correct rate, but the telescope must also rotate around an axis precisely parallel to the Earth's rotational axis. You can match the rate with a drive corrector, so that's no big deal, but the problem of making the telescope's polar axis parallel to Earth's rotational axis remains.



The standard method of polar aligning involves setting the polar axis roughly north and following a star for 10 minutes or so with the telescope at high magnification. If the polar axis is incorrectly aligned, the telescope will not track correctly and the star will slowly drift north or south out of the field of view. You then note which way it's drifting, adjust the alignment of the polar axis a little bit, and try again. Although this method works, it's frustrating and wastes a lot of valuable observing time.

But suppose there was a star located exactly at the celestial pole. All you'd need to do to align the polar axis of a telescope would be to aim the polar axis of your telescope at the pole. And if the polar axis had a built-in telescope, you could simply set the star on the crosshairs and — *voila!* — you'd have perfect polar alignment.

Well, we're not quite that lucky. But there is a bright star, second-magnitude Polaris, less than a degree from the north celestial pole (the precise distance is 48' 04''). As Earth rotates, Polaris, like other



stars near the pole, circles the north celestial pole once every sidereal day. How can we use Polaris to align on the pole? It's simple: just point the alignment telescope at Polaris, then move it the correct distance from the pole. All you then need is the direction from Polaris to the pole. Fortunately, you can find this angle using the setting circles on the polar telescope, so polefinding becomes quick and easy.

So let's begin.

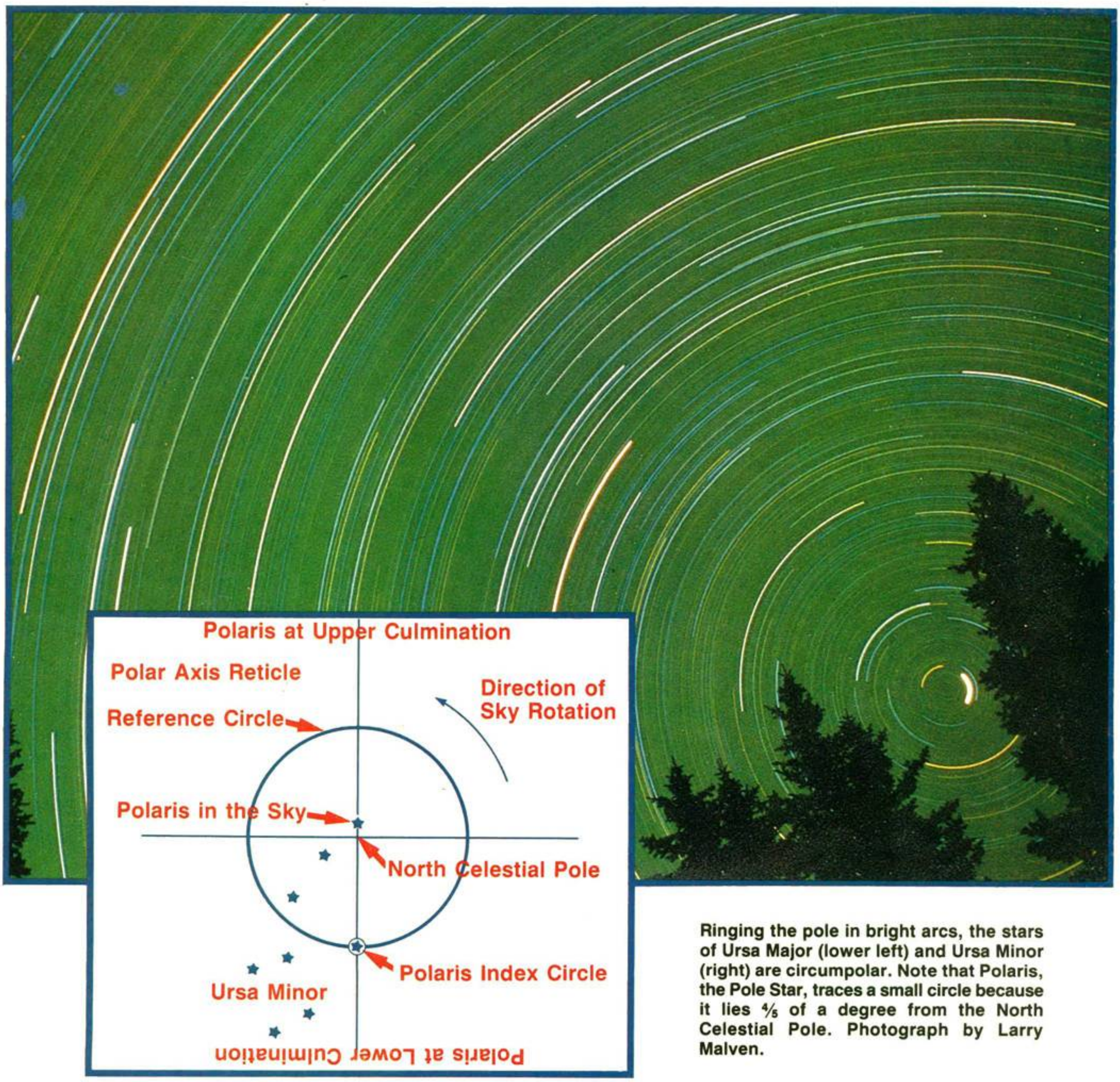
Polar Alignment Made Easy . . .

We'll start with an alignment telescope just as it comes out of the box. Set up the tripod with one leg facing the pole — reasonably close to the direction of Polaris. Disengage the drive motor, if there is one, then set the latitude scale to your latitude. By adjusting the north-facing leg, bring Polaris into the field of view. Finally, use the latitude adjustment screw for fine motion to center Polaris in the field of view of the alignment telescope.

The alignment telescope contains a reticle; when you look into its eyepiece, you'll see a circle something like what's shown on page 53. The crosshair marks the rotational axis of the telescope's polar axis, therefore it should be pointed at the pole. The reference circle marks the angular distance of Polaris from the north celestial pole — so when the mount is correctly aligned, Polaris will lie on the circle. Finally, the Polaris index circle defines the correct angular position of Polaris — when the alignment telescope is positioned correctly and when Polaris is centered in this circle, the north celestial pole will lie at the intersection of the crosshairs. Nifty, eh?

Now look at the eyepiece end of the polar alignment scope. You should see the divided circle shown above. These circles are an analog computer to help you find the angular position of Polaris. All you have to do is match the dials. Begin by dialing in the position of your observing site relative to the standard time meridian. Set this value against the index mark on the body of the alignment scope. Sound confusing? Well then, suppose you live at 69° 30′ west longitude; this is 5° 30′ east of the standard time meridian at 75° west longitude. Set the dial to 5½° east. If you live at 93° 14′ west longitude, your setting would be 3¼° west of the sixth time meridian, at 90° west longitude. Time meridians are spaced at multiples of 15°.

Next, notice that the rotating disk on the alignment scope is graduated into months and subdivided into days. The scale on the body of the mount is divided into 24 hours; this is the local time scale. Look at your watch, then convert the time into standard time on a 24-hour clock, i.e., if



Ringing the pole in bright arcs, the stars of Ursa Major (lower left) and Ursa Minor (right) are circumpolar. Note that Polaris, the Pole Star, traces a small circle because it lies ⅘ of a degree from the North Celestial Pole. Photograph by Larry Malven.

it's 9 p.m. CST, then the time is 21 hours. Don't forget daylight saving time: 9 p.m. CDT equals 20 hours.

Unlock the right ascension axis clamp and swing the scope in R.A. until the date aligns with the time of day. Using the fine adjustment screws at the base of the drive mount, place Polaris in the Polaris index circle (inscribed in the large circle in the scope's field of view). That's all there is to it — your telescope is now polar aligned! If everything is working right, the hairlines in the scope should point precisely to the position of the north celestial pole. As night progresses, Polaris will remain on the reference circle.

Time for a Tuneup . . .

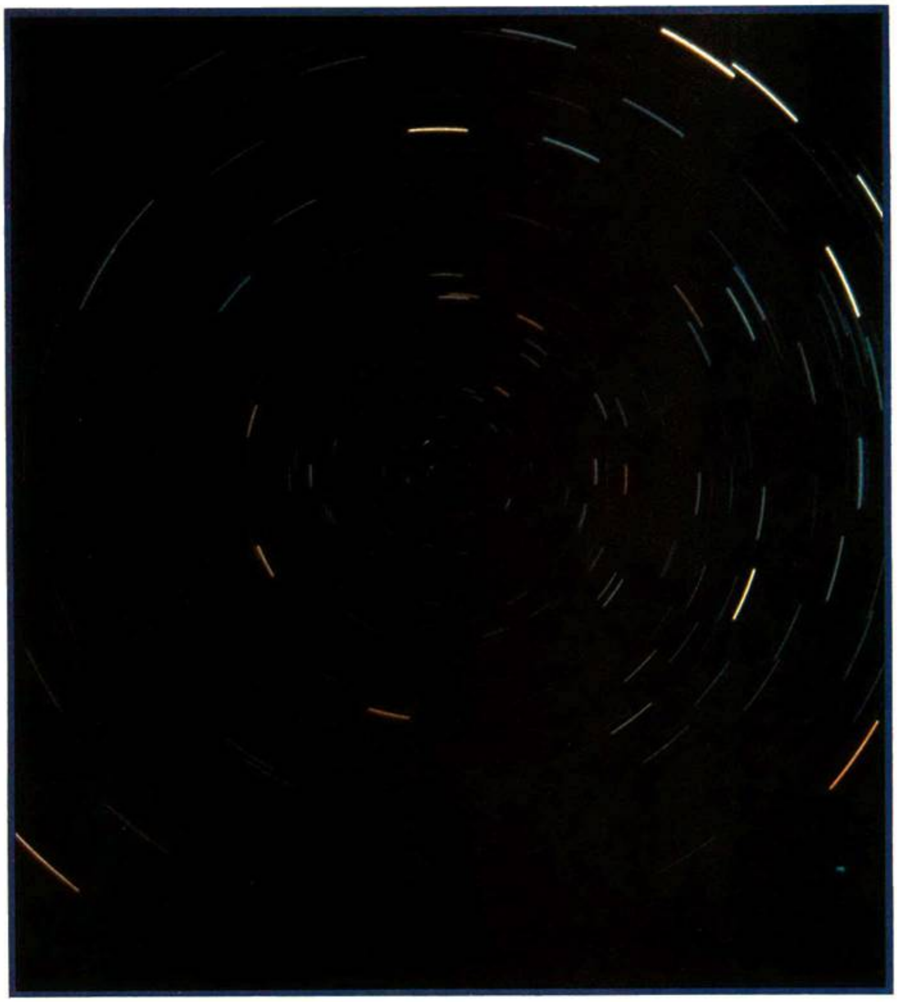
Suppose, however, that nothing works right despite your best efforts. Even though you get Polaris into the small circle, it doesn't stay with the star during the night and you need to make many small corrections while tracking a star. In that case, you'll need to calibrate the alignment telescope.

First, you must align the polar alignment telescope so that its axis coincides exactly with the polar axis of the mount. Find a bright star — even a distant streetlight will do — and place it at the intersection of the crosshairs in the alignment scope. Rotate the mount in right ascension. If the polar alignment telescope is correctly adjusted, the star will stay right on the crosshairs. If it doesn't, adjust the pointing of the polar telescope by means of the little setscrews around its periphery until the star stays on the intersection of the crosshairs when you turn the polar axis.

The second adjustment is more involved. Polaris makes a complete trip around the north celestial pole every day. At least once each day, it will be either directly above or directly below the pole. These times are called *upper* and *lower culmination*, respectively.

At the time of upper culmination, the Polaris index circle should appear at the bottom of the reference circle in the alignment telescope. Why? You forgot that astronomical telescopes invert the image! So, with all the correct values set, look into the alignment telescope. If the Polaris index circle is not at the exact bottom of the field, then the index circle is set wrong. With a small jeweler's screwdriver, loosen the tiny screw on the index mark ring. Rotate the alignment telescope to bring the Polaris index circle to the exact bottom of the field. Verify that the date and time settings are correct, then move the meridian index to the proper position and tighten the screw.

For a lower culmination, the Polaris index circle should appear at the top of the reference circle. Perform the same



Southern circumpolar stars are dim compared to those in the north — with certain notable exceptions. Bright Alpha and Beta Centauri shine at upper right; Canopus (lower right) and Achernar (lower left) also form bright trails. Faint bluish Sigma Octanis is the star nearest the pole; ruddy Chi and Lambda are the next nearest. Photograph by G. Thompson.

Polaris Times of Upper and Lower Culmination

Date	Culmination Upper	Lower
January 1	19:31	7:29
January 15	18:36	6:34
February 1	17:29	5:27
February 15	16:34	4:32
March 1	15:39	3:37
March 15	14:44	2:42
April 1	13:37	1:35
April 15	12:42	0:40
May 1	11:39	23:38
May 15	10:44	22:42
June 1	9:38	21:36
June 15	8:43	20:41
July 1	7:40	19:38
July 15	6:45	18:43
August 1	5:38	17:36
August 15	4:43	16:41
September 1	3:36	15:34
September 15	2:41	14:39
October 1	1:34	13:32
October 15	0:39	12:37
November 1	23:32	11:30
November 15	22:37	10:35
December 1	21:34	9:32
December 15	20:39	8:37

Note: Polaris culmination times are given in standard time for the meridian of that zone. The date given implies the "night of" date (i.e., May 15 means May 15/16).

checks, verify the settings, and move the meridian index to the proper position on the meridian scale.

What role does Polaris play? You really don't need it, except to check you've done the calibration correctly. So, *providing you know the time of culmination*, the calibration can be performed indoors during the daytime. Set the time, day, and meridian value for the event, and adjust the meridian index so the Polaris index circle is at the top or bottom of the alignment scope, depending on the type of culmination used. At night, check the alignment by setting up your telescope and following a star.

Polaris Culmination Times

When does Polaris culminate? Upper culminations occur when the local sidereal time equals the right ascension of Polaris. Thus, if Polaris' R.A. is 2h 16m 51s at 02:16:51 LST, you would expect to see Polaris directly above the north celestial pole in the sky — or at the exact bottom of the field of your alignment scope. Lower culminations (Polaris at the top in your alignment scope) then occur at 14:16:51 LST. This is just fine if you've got a sidereal clock.

If you don't have a sidereal clock, you can compute the sidereal time to figure out when 02:16:51 LST occurs at your longitude. But there's an even simpler way to do it. Since the telescope doesn't know where on Earth it is when you set the scales, you can simply pretend that you're on a standard meridian and consult the table above for a date and time of Polaris' culmination. Every date and time combination shown in the table will work — it's your choice.

Set the meridian dial to zero (neither east nor west) and set any pair of upper culmination values on the scales, then look into the alignment telescope. If the Polaris index circle is *not* at the exact bottom of the field, then the index circle is set wrong. With a small jeweler's screwdriver, loosen the tiny screw on the index mark ring. Rotate the alignment telescope to bring the Polaris index circle to the exact bottom of the field. Verify that the date and time settings are correct, then move the meridian index to the zero position and tighten the screw. Verify the setting using the real stars on a clear night.

So there you have it. If your telescope arrives with its polar alignment telescope properly aligned — and it should — you can set up for serious observing or astrophotography in a jiffy. But if something's out of whack, a few minutes with a small Allen wrench or jeweler's screwdriver and a little bit of fussing should set things right.

Sigma Serves the South

Southern hemisphere observers are not so lucky as their northern hemisphere counterparts. However, the 5.5 magnitude star Sigma Octanis lies just 58′ 59″ from the south celestial pole. It should not be too difficult to "eyeball" the proper position of Sigma Octanis in a reticle made for the northern hemisphere (simply place Sigma 25% further from the crosshair and in line with the Polaris index circle). Upper culmination occurs each day at 20h 54m 38s LST, and lower culmination is at 8h 54m 38s. Times of culmination for Sigma are 5h 21m before or 18h 35m after the times listed for Polaris in the culmination table.

Paul Burke is a Research Specialist at Lockheed Advanced Development Projects. An amateur astronomer since 1979, his other interests include computing, photography, cycling, and shooting.

LIST:
$4,420
$2,195
PLUS
SHIPPING

BIG APERTURE! SMALL PRICE!

Meade's Model 2120/LX 10″ Schmidt-cassegrain—complete with motor drive, all optical coatings, wedge, tripod, 8x50 right-angle finder, and all standard, factory accessories. . . . . LIST: $4,420 **NOW: $2,195**
PLUS SHIPPING

NEW! 2120/LX3—Complete with built-in Quartz-Electronic sidereal-rate drive, all optical coatings, wedge, tripod, 8x50 illuminated-reticle right-angle finder/polar alignment scope, and all standard, factory accessories. . . . . LIST: $4,490 **NOW: $2,799**
PLUS SHIPPING

Authorized
Meade
Dealer

PRICES GOOD THRU APRIL 30, 1985 ONLY, & QUANTITY IS LIMITED

CALIF. TELESCOPE CO.

P.O. Box 1338, Burbank, California 91507
Send Business-sized S.A.S.E. for FREE Discount Price List
Visa/Mastercard/Check/M.O. U.S. Sales Only
Orders Only
10am-4pm Pac. Time, Monday-Friday : **(818)505-8424**

Shown:
Quartz-Electronic Drive
Base for Model LX3, with optional
Drive Corrector Hand Control

EASY TO ORDER . . . Phone or mail your order in today. Visa/Mastercards accepted. All telescopes and mounts are shipped shipping charges collect. All mirrors, except the 29", are shipped prepaid in the continguous U.S.A. No sales tax on out-of-state orders. FREE LIST.

Showroom address: 54140 Pinecrest Road, Idyllwild
Mon.-Fri. 8 am-4:30 pm. Sat. 12-4 pm.

ODYSSEY

Visual High Fidelity Telescopes

- **30 days returnable**
- **30 days exchangable**
- **2 years materials and workmanship**

"NEVER
TOO
SMALL"

NEW! ODYSSEY 8 INCH

$239.50

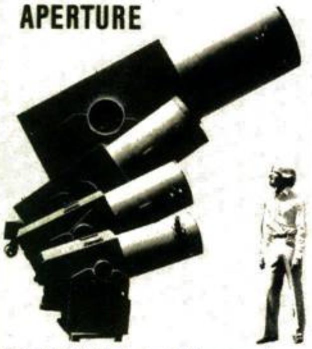
"THE WORLD'S GREATEST TELESCOPE VALUE!"*

SPECIFICATIONS

- 8" f/4.5 paraboloidal mirror with matching diagonal flat, both 1/8 wave, aluminized and overcoated.
- Super smooth and stable Dobsonian alt-azimuth mount with linear U.H.M.W. bearings. No play or backlash.
- Adaptable to astrophotography with accessories.
- Coated high performance 27mm Kellner eyepiece with chromed brass and cast aluminum 1¼" rack-and-pinion focuser.
- Durable solid white seamless plastic vinyl tube.
- Adjustable ventilated push-pull shock resistant mirror cell.
- Beautiful black, white and metallic finish.

*Aperture is the key to performance. More aperture means more light and more resolution. In comparing all the small and medium size telescopes advertised in both Astronomy and Sky and Telescope magazines, we discovered that the Odyssey 8 has the lowest cost per sq. inch of aperture. The results were dramatic! One popular 4⅛" telescope costs $14.92 per sq. inch—3 times the cost of the Odyssey 8's $4.76 per sq. inch!

LARGE APERTURE



LARGE APERTURE is the key to the success of these fine telescopes. In their sizes, they are the largest-selling low-priced telescopes in the world today.

- 1/8 wave mirror optics
- Super smooth and stable Dobsonian mounts
- Adaptable to astrophotography with accessories
- High performance coated 27mm Kellner eyepiece with precision 1¼" focuser
- Beautiful Zolatone blue finish accented with black and metallic surfaces

10.1" ODYSSEY COMPACT

This scaled-down version of the Odyssey I performs very close to its larger brother. Because of its size, it is one of a few telescopes that can be used comfortably by an observer seated in a chair. Where space, size, weight and cost are considerations, this telescope will easily put you in the large aperture class. Fantastic views of galaxies, nebulae and star clusters are the menu of the telescope.

$299.50

13.1" ODYSSEY I

This is the telescope that started it all in the spring of 1980. Experienced deep-sky observers will tell you that you'll be amazed at what you can see under a good night sky. The challenge is not to see the lime-greens in M-42, but to detect the purple-pinks, the yellow-greens, and the subtle blues. In this size telescope there is not another available that gives you so much performance at such a low, low price.

$499.50

17.5" ODYSSEY II

Here is an unusual telescope at a low, low price. The core of this telescope is the world's most popular large aperture mirror set—the famous 17.5" f/4.5. Until recently this telescope sold for $1,195.00. We reduced the price $200.00. At $995.00 it is only $335.00 more than the mirror set! Shows colors in the Ring Nebula, two or three dust lanes in M-31, and globular clusters as they should be seen.

$995.00

29" ODYSSEY 29

The world's largest production telescope. It was with this telescope that we first saw color in the Veil Nebula. This telescope gives the observer an illusion of being in space more powerful than any other telescope we've observed with. Literally outperforms any other production telescope available in the world today.

$3495.00

Coulter Optical Co.

Dept. A, P.O. Box K
Idyllwild, CA 92349
714/659-4621

"OPTIMUM OPTICS AT MINIMUM COST SINCE 1967"

ASTRONOMICAL

OPTICS

Lightweight Mirror Optics at Low, Low Prices: Pyrex, ⅛ wave, aluminized & overcoated

13.1 inch f/4.5 mirror	$254.50
12.5 inch f/6 mirror	$249.50
10.1 inch f/4.5 mirror	$134.50
10 inch f/5.6 mirror	$129.50
29 inch f/4.5 mirror	$2490.00
with diagonal	16-1 Ratio
17.5 inch f/4.5 mirror	$659.50
with diagonal	13-1 Ratio

Elliptical Diagonals

1.83"	$15.50	3.10"	$34.50
2.14"	$18.95	4.25"	$69.50
2.60"	$22.50	6.25"	$150.00

NEW! EQUATORIAL MOUNTS

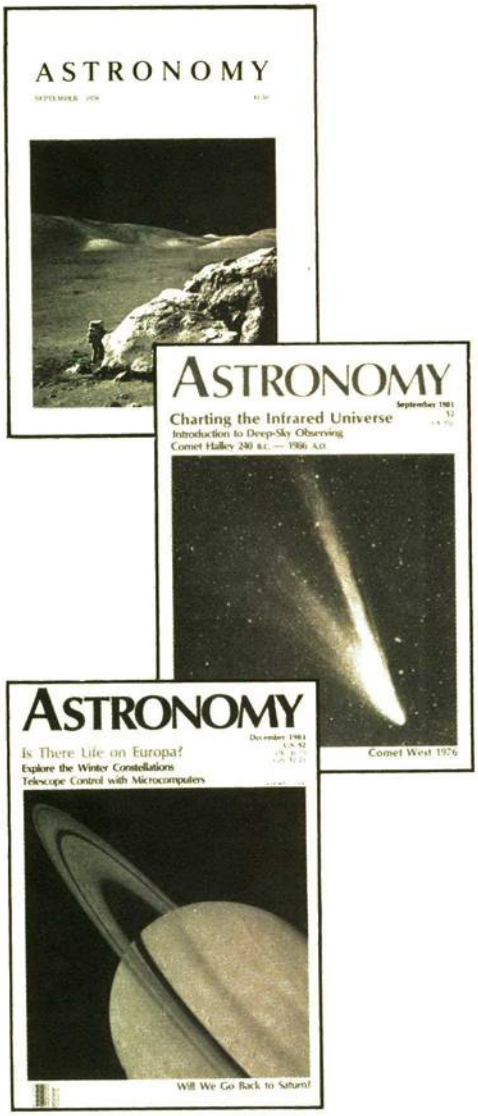
- All metal
- 2" dia. shafts
- Hollow polar shaft
- Adjustable latitude
- Super sturdy, yet lightweight
- Single arm 10.1" mount
- Double arm 13.1" mount

Compact—$249.50

Odyssey I—$379.50

Guide to Back Issues

Back Issues
Back Issues
Back Issues
Back Issues
Back Issues
Back Issues


ASTRONOMY
ASTRONOMY
September 1981
Charting the Infrared Universe
Introduction to Deep-Sky Observing
Comet Halley 240 B.C. — 1986 A.D.
Comet West 1976
ASTRONOMY
December 1981
Is There Life on Europa?
Explore the Winter Constellations
Telescope Control with Microcomputers
Will We Go Back to Saturn?

DOES YOUR ASTRONOMY LIBRARY NEED UPDATING?

Would you like to catch up on computers in astronomy? Did you miss our coverage of the historic first launch of the Space Shuttle *Columbia*? Are you looking for a Telescope Buyer's Guide? Did your subscription start just *after* our 3-part series on building a Dobsonian telescope? If you missed these or any other exciting issues of ASTRONOMY, here's your chance to complete your collection.

To order, print the month and year of those you want on the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202. Please list the issues in order by date.

— $4.00 —

August 1973: FIRST ISSUE. Hour of the Midday Night (solar eclipses), In Search of Planet X

March 1974: The Cosmic Abyss, What Happened to Comet Kohoutek?, Magnetic Fields Beyond Earth, Photography With Small Telescopes

May 1974: The Canals of Mars, Beyond the Black Hole, Jupiter, Comet Kohoutek Pictorial, Observing the Planets Beyond Saturn

September 1974: Planet of the Double Sun, Jupiter Looms Into View, Tell the Planets to Say "Cheese"

May 1975: The Search for Intelligence, Exploration from Space

June 1975: From Dust to Dust (stellar evolution), The Changing Surface of Mars, Rich Field Telescopes

July 1975: The Quest for Life on Mars, The Age of Nearby Stars, Mysteries of the Galactic Core

August 1975: Faster Than Light?, Observing the Perseids, The Great Red Spot

September 1975: Baptism of Fire, The Quasar Dilemma, Let's Take a Look at the Sun, Building a Solar Projection Screen

October 1975: Starspots on Betelgeuse, Shape of the Milky Way, Observing Jovian Detail

November 1975: Big Bang to Galaxy, Mars' New Frontiers, Find a Comet

December 1975: Astronomy from the Moon, The Planet Mercury, Stellar Beehive

— $3.50 —

February 1976: Io, Exploding Stars, The Gibbous Moon

March 1976: Beyond Space Shuttle, Infrared Astronomy, Life's Protective Shield (magnetic field reversal)

April 1976: Finding Unseen Worlds, Dust Clouds and Ice Ages, Your Most Valuable Equipment (Your Eyes)

May 1976: Quasars: Oddities of Space, Cosmic Explosions, Molecules of Life, Choosing B&W Films, Observing Galaxies

June 1976: Asteroids, Viewing the Full Moon, What You Can See Through a Small Refractor

July 1976: SPECIAL ISSUE (32 extra pages!) The History of American Astronomy. Complete from prehistory through Palomar

August 1976: Venus, Clusters of Galaxy Clusters, Exploring the Milky Way, Part 1, Red Light Sky Photography

September 1976: MOON ISSUE. The Moon's Early History, Science on the Moon, The Last Quarter Moon, Developing B&W Astrofilms

October 1976: Radio Interferometry, Searching for Mars on Earth, Birthplaces of Stars, Star-Test Your Telescope

November 1976: The Space Telescope, Black Holes, White Holes and Wormholes, Doubles, Binaries and Multiple Stars, Schmidt Cameras

December 1976: The Magellanic Clouds, Printing Your Astrophotographs, Part 1, The Messier Catalog, Cleaning Your Telescope Mirror

January 1977: MARS ISSUE. Viking on Mars: Exciting Results, Life on Mars: Ambiguous Results, Printing Your Astrophotographs, Part 2, Exploring the Milky Way, Part 2

February 1977: Uranus and Neptune, Pluto, Miniblack Holes, Cold Cameras, Part 1

March 1977: Phobos and Deimos, New Color Photos of Galaxies, Cold Cameras, Part 2, Binoculars for Stargazing: Part 2, Observing from the City

April 1977: Supernovae!, Printing Your Astrophotographs Part 3, Building a 6" Reflector, Part 1, Observing the Outermost Planets

May 1977: The End of Time, Can Life Evolve in Elliptical Galaxies? Building a 6" Reflector, Part 2

June 1977: Gamma Rays and the Origin of Cosmic Radiation, Observing with Binoculars

July 1977: The X-Ray Universe, What Makes Novae Blow Up?, Astrophotography with Telephoto Lenses, Tracking Asteroids

August 1977: Slow Boat to Centauri, Building a 6" Reflector, Part 3, Assembling Your Telescope

September 1977: Stars With Companions, Robot Probes, Building a 6" Reflector, Part 4, Light Pollution

October 1977: MARS ISSUE. The Polar Regions of Mars, Buyers Guide to Small Telescopes, "Red Variable" Stars

November 1977: The Revolution in Astronomy, The Southern Sky

December 1977: Why Do Planets Have Rings? Tunguska, Learning the Constellations, Part 1, Printing Your Astrophotographs, Part 4, Tuning in on Radio Astronomy

January 1978: Our Sun, Photographing the Sun in H-Alpha, Observing Herschel Objects, Building a 6" Reflector, Part 5

February 1978: Why Does Earth's Climate Change? Photograph the Moon!, What You Can See Through a 6" Telescope

March 1978: Swarms of Stars: Cosmic Calibrators, Rival Cosmologies, Isophote Mapping, What's Inside Your Telescope, Part 1

April 1978: Beyond Centauri, Brown Dwarfs and Black Holes, What's Inside Your Telescope, Part 2, Learning the Constellations, Part 2

May 1978: Terraforming, Blink for a Nova!, The "Big Four" Asteroids, Celestial Software, Right Ascension and Declination

June 1978: Astronomical Spectroscopy, Solar Eclipse '79, Astrophotography — With Camera Only!, Gravity, Dust and Solar Neutrinos, Naked Eye Astronomy, Part 1

July 1978: Red Dwarf Stars, What's Inside Your Telescope, Part 3, Are Galaxies Here to Stay?, Celestial Software, Telling Time, Learning the Constellations, Part 3

August 1978: EARTH ISSUE. The Early History of Planet Earth, Earth's First Oceans, What's Inside Your Telescope, Part 4, Naked Eye Astronomy, Part 2

September 1978: The Redshift Problem, The Dark Sky Paradox and the Origin of the Universe, Altitude and Azimuth

October 1978: Are Black Holes Really There?, Learning the Constellations, Part 4, Build Your Own Telescope

November 1978: ECLIPSE ISSUE. Asteroid Mining, Observing Earth from Space, Film the Eclipse!

December 1978: Pluto — Planet or Imposter?, U.K. Schmidt Pictorial, Watching the Inner Planets, Calculating Horizon Coordinates

— $3.00 —

January 1979: Are We the Only Intelligent Life in Our Galaxy?, Is There a New Lunar Crater?, Photographing Star Clusters, Hunt a Cluster

February 1979: Stellar Evolution, The Sun Will Darken!, Eyepieces: What You Get is What You See, A Revolution in Solar Physics

March 1979: Planetary Nebulae, Part 1, Nebular Filters, Patrolling the Planets

April 1979: Look Who's Moving into Our Neighborhood, Voyager Approaches Jupiter, Pioneer Venus First Results, Planetary Nebulae, Part 2

May 1979: A Voyage to Jupiter, The Great Midwinter Eclipse

June 1979: Gravity Wave Astronomy, The Moon: the Southern Highlands

July 1979: What Makes a Spiral Galaxy?, Does Cosmology Have a Future?, Brightness and Magnitude

October 1979: Buyer's Guide to Telescopes, The Top 21 Deep-Sky Objects, The Cosmological Principle

November 1979: Pioneer at Saturn, High Resolution Astrophotography, The Moon: Mountains, Basins, and Scarps, Mass Loss from Stars

December 1979: The Quasar Connection, Equipment for Observing the Sun, Tricolor Astrophotography

January 1980: Alien Eyes, Satellite Views of Earth, Wide-Field Sky Photography, Was Einstein Wrong?

February 1980: Southern Skies Explored, A (Sad) Tale of Two Comets, Cool Your Telescope, Are Blazars Quasars?

March 1980: The Colors of Deep Space, The Cooling Fire of Creation, Photographing the Sun, Building a Sundial

April 1980: Return to the Moon, What Accessories Do You Really Need?, Using SO-115 Film

May 1980: The Colors of Mars, Asteroids: The Flying Mountains, The Afro-Indian Shadow Connection, An Album of Galaxies, Sunspots

June 1980: Cosmic Contamination, KAO: Mission Incredible, How to Build a Dobsonian Telescope Part 1

July 1980: The Great Red Spot, Mysterious Pluto, Stalking the Gaseous Nebulae, How to Build a Dobsonian Telescope, Part 2, The Puzzle of SS-433

August 1980: Journey to the Center of the Galaxy, Constellations of the Milky Way, How to Build a Dobsonian Telescope, Part 3, Extraterrestrial Climate Threats

September 1980: Four New Worlds (Jovian Satellites), 21 Challenging Deep-Sky Objects, A Darkroom for Astrophotography, What's My F-Ratio?, The Lively Meteorites

October 1980: Why All the Fuss About Quasars?, How to Buy a Telescope for a Child, Getting the Most from Your Deep-Sky Negatives, Space, Time and Black Holes

November 1980: An Imaging Revolution (Electronics), Universe: Time Zero, North American Solar Eclipses: The Next 50 Years, Processing Your Astronegatives

December 1980: Of Transits and Timeballs, Keeping Warm While Stargazing, The Moon: Ring Mountains and Walled Plains

— $2.50 —

January 1981: Voyager 1 at Saturn, Winter Hunting, Observing Planets in the Daytime, Making Astroprints

February 1981: Voyager: Science at Saturn, Cold Camera for Astrophotography, All About Telecompressors, Observing Peculiar Galaxies.

March 1981: Venus by Radar, Observing Gas Giants, Bare-Bones Astrophotography, Solar Magnetism

April 1981: The Tektite Controversy, Mining a Meteor Crater, Hypersensitizing, Part 1, All the Angles on Magnification, Image Orientation, The Fallen Sky

May 1981: The Solar Maximum Mission, The View from Io, The Moon: Rilles and Wrinkle Ridges, Hypersensitizing, Part 2, The Invisible Universe

June 1981: Probing the Chemistry of Galaxies, Observing Planetary Nebulae, Getting the Correct Exposure, Flare Stars

July 1981: Mars: 5 Years After Viking, The Electronic Sky, July's Lunar and Solar Eclipses, The Age of the Universe

August 1981: Space Shuttle, Watch for the Meteors, Beginner's Guide to Telescope Types, Saturn Update

September 1981: Mr. Halley's Hairy Star, The Pleasures of Deep-Sky Observing, Handcrafted Homebuilt Telescopes, The Infrared Universe, Part 1

October 1981: The Star Clouds of Magellan, 1981 Telescope Buyer's Guide, Starting an Amateur Astronomers Club, The Infrared Universe, Part 2

November 1981: Voyager 2 at Saturn, Observing for Pleasure — Urban Astronomy, Cold Camera vs. Gas Hypering, Stellafane and the Art of Telescope Making

December 1981: The Saturnian Moons, Is That Lens a Star Performer?, Paint the Night Sky on Your Ceiling, The Search for Extrasolar Planets

January 1982: The Three Suns of Centaurus, Making the Most of Black-and-White Astronegatives, Equatorial Platforms, Caution! High Winds Beyond this Point

February 1982: The Galileo Mission to Jupiter, Cameras for Astrophotography, How to Reduce Tracking Error, A Closer Look at Saturn's Rings

March 1982: Secrets of Interstellar Clouds, How to Plan a Newtonian Reflector, The 2415 Revolution, The Molecules Between the Stars

April 1982: The Incredible Skies of Mauna Kea, Do Supernovae Trigger Star Formation?, Alt-Azimuth Setting Circles, Bloopers, Alien Skies.

May 1982: The Planets or Bust, Topography of the Terrestrial Planets, Making Black and White Slides, An 8-inch Telescope, The Glass Giant of Palomar

June 1982: The Electromagnetic Spectrum, Rethinking Your 60mm Refractor, How Much Sky Can My Camera Capture? The Vanishing Act of Carbon Giant

September 1982: Solving the Mysteries of Venus, Astronomy in the Garden, What Heats the Solar Corona?

November 1982: Looking Inside Quasars, Film Loading Tips, Galactic Coronas, 21 Objects for Binocular Observers

December 1982: A Celebration of Light: Yerkes in Perspective, A Year's Harvest of Pictures, Contact Binaries: Stars That Touch, The Telescope Revolution

— $2.00 —

January 1983: To Sculpt the Galaxies, Space Art in Hawaii, A Mini-Observatory for Your Backyard, The Great 1983 Almanac Skychart

February 1983: Vesta: A World of Its Own, From Chaos to Consciousness, Capturing Deep Sky Objects on Paper, Backyard Photoelectric Photometry, Off-Axis Guiding

April 1983: Voyager to Uranus and Neptune, Venus Radar Mapping Mission, Sketching the Moon and Planets, How to Star Test Your Telescope, Infra-Red Astronomical Satellite

August 1983: Celestial Winds, Polar Lights, Comet Swift-Tuttle and the Perseids, 50 Finest Double Stars for a 60mm Refractor, Amateur Astronomy and the Home Computer

September 1983: Return to the Planets, Four Probes to Comet Halley, Total Solar Eclipse in Java, Short Focus Photography, X-rays from Stars, Binoculars and Binaries

November 1983: Geology from Space, Simple and Inexpensive Tricolor Photography, The Decay of the False Vacuum, Studying Galactic Structure with Binoculars, Part 2

January 1984: A Bigger and Better Milky Way Galaxy, Add Drama and Interest to Your Astrophotos, Clocks and Calendars for Astronomy, Possible Planets, Part 1

March 1984: IRAS and the Infrared Universe, Probing the Constellations of Spring, The Planck Era, A Homemade Finder Scope Mount

April 1984: Superclusters: Giants of the Cosmos, Stars Too Small to Burn, Astronomy From the Shuttle, Computing Times of Sunrise, Sunset and Twilight

May 1984: Planetary Atmospheres, How to Observe and Photograph the Annular Solar Eclipse, MMU: Man Flies Free

June 1984: Space Stations: The High Frontier, The Star Tar in the Jupiter Jars, Cosmic Jets: Bipolar Outflows in the Universe, How to Observe Satellites

July 1984: White Dwarfs: Big Things in Small Packages, Those Amazing White Dwarfs, Report on VR-1000, A New Source of Cosmic Rays?, Make Your Dobsonian Telescope Easier to Use

August 1984: Astronomical Ballooning, Spectral Visions, Part 1: The Long Wavelengths, Isophote Mapping, Observing the Sun, The Coming of Epoch 2000

September 1984: Solar Max Returns, IRAS Views the Galaxy, Spectral Visions, Part 2: The Short Wavelengths and Beyond, Against All Odds: Matter and Evolution in the Universe, Building an Equatorial Tracker for Astrophotography

November 1984: Mystery of the Missing Mass, Fossils of Something Interesting: The Large-Scale Structure of the Universe, Television in Astronomy, Part 1, Does Space Have More Than Three Dimensions?, Photographing Meteors in Winter

December 1984: Soviets to the Moon: The Untold Story, Television in Amateur Astronomy, Part 2, Tuning into the Interior of a Star, Successful Schmidt Camera Photography

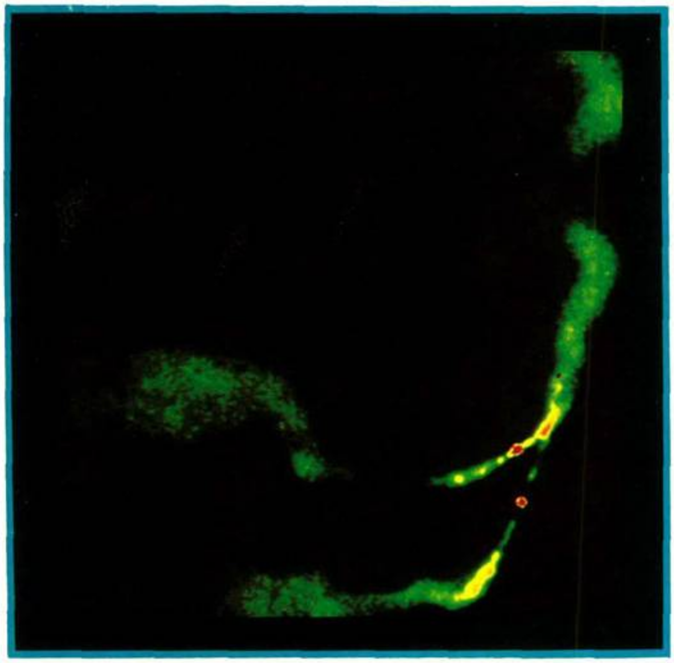
January 1985: The Universe, Bit by Bit, The Observatories of Jai Singh, Exposure in Astrophotography, How to Revive a Tired Astronomy Club, Can Comets Become Asteroids?

February 1985: Through Monster Eyes, Discovering the Expanding Universe, Find Halley's Comet by Blinking, An Intensified Evening at the Telescope, Astronomical Ballooning 2, Computing the Ephemeris of Comet Halley

March 1985: Comets: Keys to Our Solar System, The Return of Halley's Comet, Comets, "Death Stars," and Extinctions, Making an Astrophotographic Mosaic, Build a Simple Folded-Refractor Telescope

April 1985: British Astronomy Reaches New Heights on La Palma, Eclipse Over Oceania, Build a $6 Eyepiece Warmer, Cold Dark Matter and the Origin of Galaxies

ASTRONEWS



NRAO

3C 75's Quadruple Jets

A strange radio galaxy with a double nucleus has been found to emit four enormous jets from its center — the first such object ever known. The galaxy, 3C 75, is the central member of Abell 400, a cluster of some 50 galaxies roughly 300 million light-years away in the direction of the constellation Cetus.

Radio source 3C 75 and its jets were first photographed with a 36-inch telescope at Kitt Peak, but the images lacked detail. Recently, astronomers Frazer Owen, Christopher O'Dea, Makoto Inoue, Jean Eilek, and Richard White turned the high-resolution Very Large Array (VLA) radio telescope on the object.

The false-color radio photo shows 3C 75's double nuclei as two tiny red spots, each flanked by the tangled wispy "smoke" of the jets. Both nuclei are about a light-year across and separated by 20,000 light-years; they are probably linked gravitationally.

The jets put out 100 million times the energy of the Sun and consist of streams of high-energy relativistic particles, which both radiate on their own and have entrained already-hot intergalactic material and perhaps picked up some energy from it. Their temperature is about 30 million degrees Kelvin. Owen and his colleagues were surprised that all the jets bend in the same direction, and attribute this to a possible flow of gas belonging to the parent cluster. The main source of energy for the jets comes from powerhouses in the nuclei — perhaps violent regions surrounding two black holes.

"This is a very mysterious object," Owen notes, adding that it will require a lot more work to understand fully how the jets and nuclei operate.

Spacelab: Earth Observations

The most visually-exciting results from Spacelab 1's mission on STS-9 came from photographing the Earth with the metric camera: a modified 305mm Zeiss aerial survey camera that makes photos 9 inches square. The purpose of this instrument was to see whether medium-scale maps (1:50,000 to 1:200,000) could be printed directly from orbital photographs. Topographic charts in those scales are invaluable for calculating locations and quantities of natural resources.

Since mapping with aerial photos is slow, cumbersome, and expensive, 60 percent of the Earth's land surface remains unmapped. Not surprisingly, resource maps of developing countries are few. However, the techniques pioneered aboard Spacelab are economical and efficient. A single photo from orbit can provide the detail and surface coverage of several maps laboriously compiled through normal aerial photography.

The metric camera took more than 1100 photographs in high-resolution black and white, 550 in color infrared, and 450 in black and white infrared. The photos were taken at a scale of 1:820,000 and covered an area 190 km square. To get stereo for determining topography, the photos overlapped 60 percent. These stereophotos can be used to produce detailed 50-meter contour maps — previously nonexistent for many areas.

Eleven million square kilometers were photographed, 70 percent of which was cloud-free or only partially covered; all frames were usable to some extent. To compensate for poor lighting conditions, some exposures were taken at $\frac{1}{500}$- and $\frac{1}{250}$-second rather than the planned $\frac{1}{1000}$-second needed to freeze image motion. Despite these difficulties, the photos were the best ever taken of Earth from space.

At present, the images are being analyzed to see how well they will work for maps. This depends on the actual ground resolution achieved, but preliminary scrutiny reveals that roads 10 meters or more wide can be seen easily. With typical city views, a 10x enlargement reveals virtually every street and many landmarks.

Although photographic objectives were achieved, the metric camera will be reflown later this year to shoot areas previously hidden by cloud. *Aldo Rabaiotti*

Manned Lunar, Asteroid, and Mars Missions

A recently completed study has assessed the cost of three future missions to continue manned exploration of the solar system. This is the first serious analysis of manned solar system flight since Apollo and incorporates new technology based on the Space Shuttle and other developments of the 1970s.

Looking at the most ambitious project, the study (sponsored by the Planetary Society) found a mission to Mars, using much already existing technology, would cost about half that spent by NASA to get the first astronauts to the Moon. Other missions examined include a Moon flight to pave the way for a permanently-staffed lunar base and exploration of a near-Earth asteroid.

The lunar mission would have four crew members and be geared toward establishing the best possible site for a permanent lunar base. The mission would last 30 days and cost about $17 billion. (All costs are in FY 1984 dollars.) The three-man mission to a near-Earth asteroid would also cost about $17 billion and last almost two years.

The Mars mission, involving a crew of four and a 30-day surface stay, would cost about $38 billion and take three years from launch to return.

These costs are in line with the $17 billion development cost of the Space Shuttle and the estimated $10 billion development expenditures for the Space Station. In comparison, the Apollo lunar explorations cost $75 billion. "While missions to Mars with human crews cannot be justified on scientific grounds alone," says Carl Sagan, president of the society, "they provide promising opportunities for international cooperation.

"They [the missions] represent a readily-grasped intent, especially if undertaken by the United States and the Soviet Union, to work on behalf of the entire human species," says Sagan.

Here is a synopsis of the plans:

The Lunar Option:

Four trips from low-Earth orbit using the Space Shuttle and orbital transfer vehicles (OTVs) will be required to get four astronauts and their equipment to the lunar surface. Once there, the astronauts will split into two teams, both having exploration vehicles consisting of a rover and a trailer equipped with crew quarters and laboratory facilities.

The Asteroid Option:

The typical mission to a near-Earth asteroid would last two years, have a three-person crew, and would explore asteroid 1982 DB, an Earth-crosser. The primary mission includes a flyby of another asteroid, 1577 Reiss, at 4.7 km/sec. The mission would require nine Shuttle launches and two OTVs.

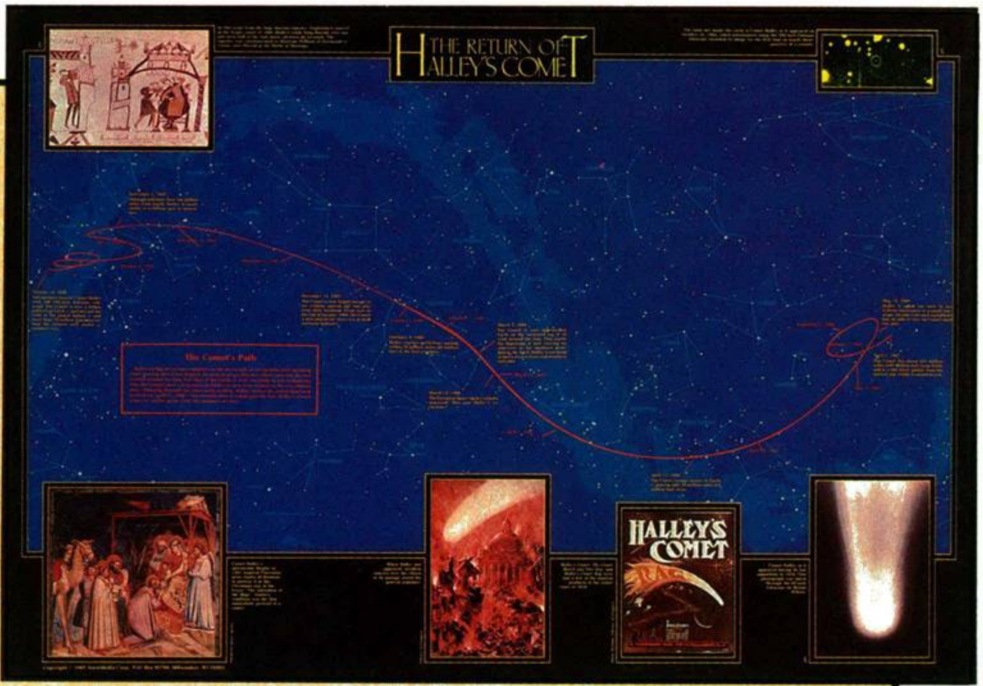
Astronauts will explore the asteroid wearing spacesuits and MMU-type backpacks, while the spacecraft remains flying in formation a safe distance away. On the surface, astronauts will recover core and surface samples from sites previously selected while on the spacecraft.

The Mars Option:

This mission has a four-person crew, three of which will explore the martian surface. Ten OTVs and 18 Shuttle missions will be required for the three-year-plus mission (six months outbound trip, 30 days exploration, and two-and-a-half year return).

Surface work will require a mobile geophysics laboratory, high-resolution cameras, temperature, seismic, and soil-composition samplers, deep-core drills, sensors to log core hole samples, a mortar for seismometer experiments, and other miscellaneous support equipment. About 250 kg of surface samples would be brought back to Earth.

Display Comet Halley On Your Wall



- Accurate
- Scientific
- Historic
- Useful
- Handsome
- Unique

When Halley's Comet returns this year, keep up-to-date on where it is with **THE RETURN OF HALLEY'S COMET** from AstroMedia. Measures 21" x 30", suitable for framing. Order now!

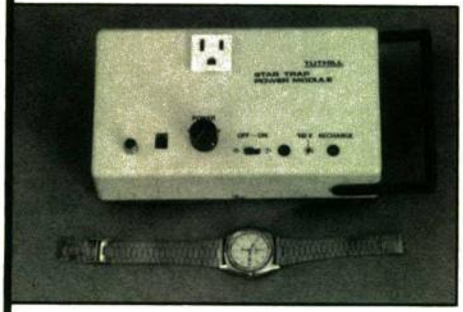
THE RETURN OF HALLEY'S COMET

$4.95

Gift Idea: Buy 2 — Get a 3rd FREE!

To order, use the AstroMedia order form bound into this issue, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

WE ARE THE ASTRONOMICAL INNOVATORS YEARS AHEAD OF EVERYBODY



**MODEL # 1
for other scopes**

Our rechargeable STAR TRAP POWER MODULE makes the Super C8 CORDLESS!! As a bonus the STPM becomes a full-fledged dual-axis, BUILT-IN DRIVE CORRECTOR when needed!! Convenient? You BET! Think of it. NO CORDS of any kind when you want to drive your scope for viewing or astrophotography! A DREAM COME TRUE!

The STPM is easily field mountable INSIDE the base of the Super C8 with simple tools, and without soldering. If your Super C8 doesn't have a STPM with its built-in rechargeable battery it is OBSOLETE! Model #1 available for other scopes.

TUTHILL
STAR TRAP POWER MODULE
OFF—ON
12V

**MODEL #2
for Super C-8**

We also sell Solar Skreen® Sun filters, huge 50mm & 80mm right angle finders, PLOSSL eyepieces, a Precision Polar Axis Finder, a Stereoocular viewer, No Du Caps, Digital displays, Isostatic Equatorial Mounts and lots of other goodies for the amateur.

CALL TOLL FREE 1-800-223-1063

In NJ call 201-232-1786

Send a large (9" x 12" — 3 oz.) MANILA Self-Addressed Stamped Envelope for our Complete Information Kit including "Tuthill's Twenty-Two Telescope Tips."

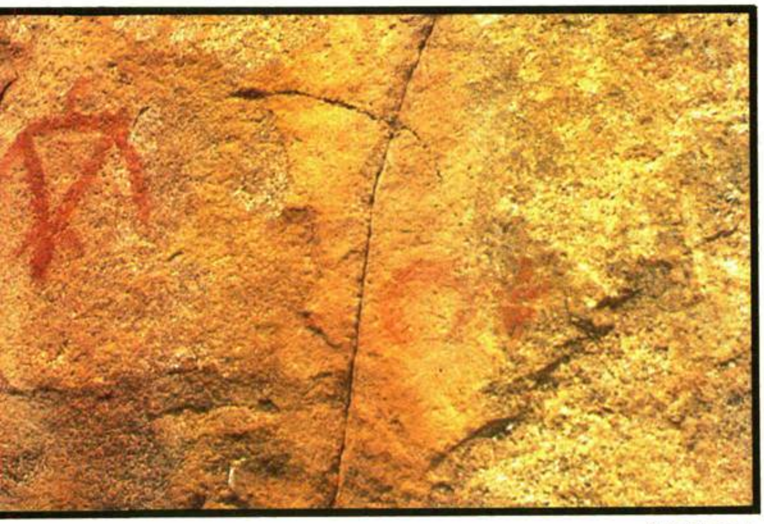
WE REPAIR **CELESTRON*** SCOPES

ROGER W. TUTHILL, INC.

MasterCard VISA *Trademark

11 Tanglewood Lane, Dept. A, Mountainside, N.J. 07092

ASTRONEWS



G.W. Collins II

"New" Depiction of the Crab Supernova Found?

The explosion of the Crab supernova in July 1054 was awe-inspiring. At maximum brightness, it was almost 10 times brighter than Venus and could be seen in daytime for three weeks. The supernova finally sank below naked-eye visibility after two years. Most of our information about its appearance has come from Chinese astronomical annals — they leave no doubt that this "guest-star" was a very impressive sight.

But the Chinese weren't the only ones to observe and record this supernova. Since the early 1950's, pictographs at various sites in the American southwest have been found which probably depict the brilliant event. These pictures commonly include a crescent Moon — rare in Amerindian art — which supports the theory that they depict the Crab supernova. Computations have shown that a waning crescent Moon passed near the supernova on the morning after it erupted, as seen from western North America. But up to now, all the pictographs found have been in the arid southwest.

While leading a Scout canoe trip through Quetico Provincial Park, Ontario, astronomer George Collins of Ohio State University passed by a 200-foot high cliff facing south-southeast. The cliff is on Ahsin Lake, two days from the nearest road. On the cliff near water level, Collins noticed some red ochre pictographs. Among several thunderbirds and a canoe was a curious drawing (see photo). "Being an astronomer, I immediately thought 'the Crab supernova!'," he says. But is it?

Collins' find is not original with him; the cliff had already been documented in the late 1950s by Selwyn Dewdney, a Canadian artist and anthropologist who was surveying pictograph sites for the Royal Ontario Museum in Toronto. Dewdney's hand-drawn record shows the pictograph as looking more like a stylized bear than a crescent Moon and star. Yet Dewdney, working in an anthropological context, was probably unaware of possible astronomical connections.

As a site for viewing the rising supernova and Moon, the lake is quite good. From the base of the cliff where the painting is located, the conjunction of Moon and supernova would have been visible over the artist's right shoulder at an elevation of about 5° to 10° at dawn. On a calm, clear morning, the conjunction coupled with its reflection in the still lake would have made an awesome sight.

If it *does* portray the Crab supernova, then this is the most northern and eastern Native American depiction of the event yet found.

One contemporary anthropologist to whom Collins showed his photo of the pictograph said he'd "buy the Crab" only if there was no ochre paint between the crescent and the star — otherwise, it was probably just a drawing of a bear. Unfortunately, the cliff wall is discolored by an evaporite deposit (lime, perhaps) precisely between the crescent and the star — or at the bear's neck.

The evaporite may provide a means of estimating a crude age for the pictograph. Collins hopes to return to the site, accessible only by canoe, and carry out detailed photographic studies to explore the possibility of determining the painting's age. If 1,000 years old, this would make it hard to resist speculation that ancient man paused on the morning of July 5, 1054 to leave a message for posterity.

Abundant Lithium Found in Star Cluster NGC-7789

By the time a star becomes an old, bloated red giant, it has consumed much of its hydrogen and has developed an appetite for fused helium and other light materials. It has also exhausted its sparse supply of lithium — a pale, reactive, fragile metal which is so rare in nature that astronomers use it to probe the structure and evolution of stars.

At least that is what red giants are *supposed* to do.

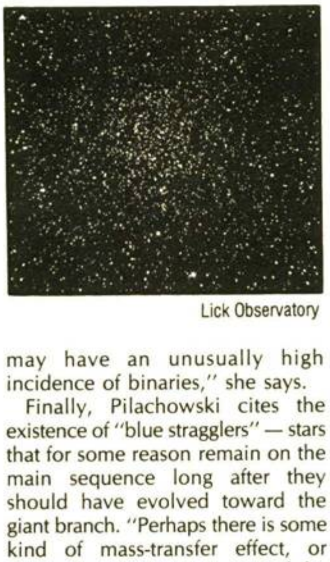
In mid-January, at a meeting of the American Astronomical Society in Tucson, Catherine A. Pilachowski of Kitt Peak National Observatory reported on her measurements of lithium in the old star cluster NGC-7789, which formed 1.5 billion years ago and lies 7,200 light-years away. Some of the red giant stars in NGC-7789 still have 10 times as much lithium as red giants outside of clusters. This anomalous lithium abundance means that the red giants in NGC-7789 do not behave the way "normal" red giants do: perhaps they are not using up lithium as efficiently, or are somehow manufacturing lithium as they undergo thermonuclear reactions. Or perhaps their surfaces are affected by companion stars, whose gravitational influence might control the depth of the lithium-mixing layer in them.

The process of lithium depletion in stars is one of the few direct observations available to astronomers studying the internal dynamics of distant stars. In this process, lithium is destroyed as material from the star's surface becomes mixed into the hot interior. Below the surface, a convective mixing zone circulates the material to a depth where temperatures reach millions of degrees — more than hot enough to destroy lithium. According to Pilachowski, the giants are composed of a hydrogen-burning shell around an inert core of helium, which is not yet sufficiently pressurized to ignite. "As stars develop this mixing region," she says, "you see less and less lithium. Then, as the star branches off as a red giant, lithium abundance drops dramatically. The amount of lithium in giants should be undetectably small."

About a year ago, Pilachowski and her colleagues began to look for lithium in NGC-7789, expecting to find none. Instead, they found so-called cosmic levels — about one lithium atom for every billion hydrogen atoms. Why? Pilachowski says, "We see several possibilities. The first was that the cluster stars somehow began with higher than cosmic quantities of lithium. We have ruled that out by the observation of lithium in unevolved main-sequence stars." Another possibility, she says, is that solitary giants deplete their lithium faster than giants in open clusters. "But we don't know how they could do this. The problem with field giants is that, since they are not in a cluster, we really don't know how far away, how old, or how massive they are."

Alternatively, both single and cluster giants could deplete their lithium at the same rate if the cluster giants could somehow manufacture more. Pilachowski says, "It is very hard to invent some bizarre process to do this that other stars would then have to exhibit too."

The most promising hypothesis is that binary stars exert some influence on the giants and control the rate at which lithium is depleted by the star. "Interestingly enough, NGC-7789 may have an unusually high incidence of binaries," she says.



Lick Observatory

Finally, Pilachowski cites the existence of "blue stragglers" — stars that for some reason remain on the main sequence long after they should have evolved toward the giant branch. "Perhaps there is some kind of mass-transfer effect, or delayed evolution, because of the binaries."

The reason for monitoring lithium, she explains, is that its sensitivity to temperature makes it a good tracer of the internal temperature of a star, affording scientists a view of the convective structure within. But the abundance of lithium also has cosmological implications. "We don't know how the universe makes lithium," Pilachowski says; "we see that some lithium must have been made *in the* Big Bang, and some through interaction with cosmic rays. This gives us two flavors, lithium 6 and 7, from the Big Bang, and

ASTROMART

AstroMart listings are free to all our readers for non-commercial purposes — but only 2 per person per year, please. Limit your ad to 40 words including your name and address and allow 4 to 6 months for it to appear. All ads are subject to review for suitability. AstroMedia assumes no responsibility for statements made in classified ads, nor for the quality of advertised items.

ANNOUNCEMENT — Attention New York and Long Island stargazers. The Amateur Observers' Society of New York meets the first Sunday of each month at the Vanderbilt Planetarium, Centerport, New York. We always have plenty of room for beginners. For details, phone Barry at (516) 541-1690 evenings.

ANNOUNCEMENT — The Astronomical Society of Greenwich invites everyone in Greenwich and surrounding counties to attend their meetings which are held on the first and third Wednesday of each month at 7:30 p.m. in the Bruce Museum. For information, phone the Bruce Museum at (203) 869-0376.

ANNOUNCEMENT — The Campaign for Space PAC is the nation's first citizen-supported, non-partisan political action committee. Join thousands of involved citizens in taking the pro-space message to Washington. For information, our newsletter, and more, write P.O. Box 1526, Bainbridge, GA 31717.

ADVERTISER LISTING

ADVERTISER	PAGE
AAA Travel Agency	61
Ad-Libs Astronomics	31
American Tool & Toy	61
Astro Cards	73
Astroline Products	72
Astronomy Book Club	64-65
Bergen County Camera	61
Berger Bros. Camera	73
Bushnell	29
Calif. Telescope Co.	55
Celestron International	27,87,88
Cosmic Connections, Inc.	73
Coulter Optical	55
Focus Camera	34
Hayes & Nolly Productions	48
Interesting Software	63
J & S Enterprises	73
Jim's Mobile Ind.	72
Lumicon	49,74
Meade Instruments	2-3
Meteorites	73
Mibro Co., Inc.	63
New England Astro-Optics	73
New York Camera	66
Northeast Instruments	72
Optics Ohio	73
Orion Telescope Center	23
Parks Optical	50
Pauli's Optical	72
Quasar Optics	72
RBP	63
Rainbow Adventure Holidays	63
Scope City	40
Sky Instruments	72
Star Tracker	72
TeleVue	74
Texas Nautical Repair	73
Towson Photo Supply	73
Tuthill, Roger W.	59
VERNONscope & Co.	41

ANNOUNCEMENT — Join the Midlands Astronomy Club of Columbia, South Carolina. We meet the first Thursday of every month at 7:30 p.m. at the Richland Arts School of Columbia Museums, 1112 Bull St. Phone Wade Thompson at (803) 772-1795 or write Box 477, White Rock, SC 29177.

ANNOUNCEMENT — New astro group being organized in north Arkansas by Past President of the Chicago Astronomical Society. Contact Joseph Anderer, Route 6, Box 120R, Mountain Home, AR 72653. Phone (501) 492-6366.

ANNOUNCEMENT — Computer programs for Atari, Apple, T/S 1000, and ZX81 are available from the Waterloo Amateur Astronomy Society. Programs include Solar System Almanac, Messier Catalog, Meteor Database, and Conversions. For listing, contact W.A.A.S., 25 Bridgeport Rd., Waterloo, Ontario, Canada N2J 2J4.

ANNOUNCEMENT — We're looking for people in the Staten Island, New York area interested in forming an astronomy club. Phone Thomas Raney at (718) 948-0657.

RENAISSANCE™
By TeleVue

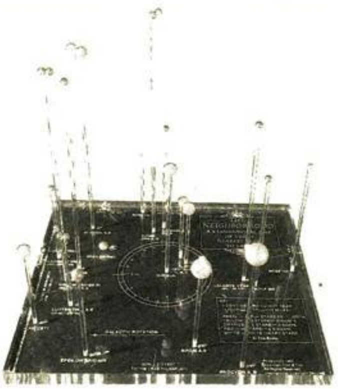
TeleVue Eyepieces
- **Nagler**
- **Wide Field**
- **Plossl**

CELESTRON®
PRECISION OPTICS

TELESCOPES & ACCESSORIES
CALL OR WRITE FOR INFORMATION

Bergen County Camera
270 Westwood Ave.
Westwood, NJ 07675
201-664-4411

THE GOLDEN AGE OF ASTRONOMY
THE STAR FIELD TO TAU CETI



3-DIMENSIONAL STAR MAP!

"THE NEIGHBORHOOD" is an exciting new view of our place in the galaxy in relation to our immediate stellar neighbors. Praised by astronomers worldwide.

Sol To Tau Ceti complete (12 light-years)
8"x9" acrylic base w/27 color-coded stars $28.00
Sol To Sirius complete (≈9 light-years)
4½"x6" acrylic base w/9 color-coded stars $15.00
(40-page booklet included with either projection)
"The Star Field to Tau Ceti" (Booklet only) $4.00

Send check or money order payable to:
American Tool & Toy,
5116 Buckingham,
Detroit, MI 48224
Allow 2-4 weeks for delivery.
Please include name and address.

ANNOUNCEMENT — The Sacramento Valley Astronomical Society welcomes everyone to attend their meetings held on the third Saturday of each month at the Sacramento Science Center and Junior Museum. For more information, phone (916) 485-4471.

FOR SALE — Lumicon Super-Finder with 80mm objective, 300mm focal length, star diagonal, full aperture Mylar solar filter, 6-inch dewcap, objective, dustcap, and standard tripod adapter. Excellent condition, $115 postpaid. Contact Charles Strickland, 4606 Martha Ave., Pensacola, FL 32506. Phone (904) 453-1016.

FOR SALE — Meade DS-16" Newtonian with clock drive, S.M. declination control, 6" setting circles, 8x50 finder, 2" focuser, Lumicon off-axis guider, 25mm Kellner eyepiece. Two years old, $1500. Contact D. Pray, 40 Hillcrest Dr., Cranston, RI 02920. Phone (401) 946-0561.

HALLEY'S COMET

Don't miss this
ONCE IN A LIFETIME EVENT

January 7–19, 1986
Transcanal cruise on
SITMAR'S Luxurious FAIRSEA

OR

March 12–22, 1986
Caribbean cruise on
SITMAR'S fabulous FAIRWIND

Guest lecturer for both cruises:
DR. DAVID MENKE
Executive Director,
Copernican Space Science Center

Experience the wonders of this celestial event while enjoying the inimitable luxury of a Sitmar cruise.

FAIRWIND & FAIRSEA:
Liberian Registry.

Special group departure
1985 prices.

AAA
TRAVEL AGENCY

AAA Travel Agency
815 Farmington Ave.
W.Hartford,CT 06119
203/233-8511

Contact:Jane Kuhn, Group Travel

ASTRONEWS

lithium 6 from cosmic rays. Some may be made by novae, too. In the stars we see lithium 7."

The amount of lithium produced that can be attributed to the Big Bang constrains whether the universe is open or closed — whether it will expand eternally or eventually be drawn back into the ultradense pellet of matter from which everything may have begun. If lithium is abundant, this implies that the initial particle density was high enough during the Big Bang to close the universe. "But the lithium abundance we see is so much less that the universe must be open . . . you would need about 20 times more than the cosmic abundance to close the universe," Pilachowski says.

"Still," she adds, "the question remains, how much was made by the Big Bang, and how much has been made since?" She cites the work of French researchers at the Mauna Kea Observatory in Hawaii, who found lithium in metal-poor dwarf stars a factor of 10 below the cosmic abundance — about one lithium atom for every 10 billion hydrogen atoms. This corresponds well with the older stars Pilachowski observed in NGC-7789. She muses: "Has lithium increased steadily, over all this time? We are still trying to get more points for the curve."

ASTRO CALENDAR

May 2-4
MAPS '85 (Middle Atlantic Planetarium Society), Hayden Planetarium, New York City, New York. Contact: Tom Carey, Vanderbilt Planetarium, Centerport, NY 11721. Phone (516) 757-7501.

May 13-19
Texas Star Party, Prude Ranch, Fort Davis, Texas. Contact: TSP '85, Dept. A, 128 N. Commerce, Burleson, TX 76028.

May 17-18
Burke Lake Telescope Meet, Burke, Virginia. Contact: John S. Huggins, 5608 Flag Run Dr., Springfield, VA 22151.

May 22-24
IAPPP Big Bear Symposium, Camp Oaks, Big Bear, California (same location as Riverside Telescope Maker's Conference). Contact: Rev. Donald L. Rohe, 957 W. Marshall Blvd., San Bernardino, CA 92405. Phone (714) 383-4731 or (714) 883-7923.

May 24-27
Riverside Telescope Maker's Conference, Camp Oaks, Big Bear, California. Contact: Cliff Holmes, 8642 Wells Ave., Riverside, CA 92505. Phone (714) 689-6893.

May 25-29
Planetarium Association of Canada Biennial Conference, Toronto, Canada. Contact: Chris Sasaki, McLaughlin Planetarium, 100 Queen's Park Crescent, Toronto, Ontario, Canada M5S 2C6.

June 7-8
15th Annual Apollo Rendezvous and Telescope Fair, Dayton, Ohio. Contact: Chairman, Apollo Rendezvous, P.O. Box 20268, Dabel Branch, Dayton, OH 45420.

June 9-12
Southeastern Planetarium Association Annual Conference (professional conference), Land Between the Lakes, Kentucky. Contact: Doug Gegen, Visitor Center, Land Between the Lakes-TVA, Golden Pond, KY 42231. Phone (502) 924-5602.

June 17
3rd American Workshop on Cometary Astronomy, Tucson, Arizona. Contact: Steve Edberg, Jet Propulsion Laboratory, 4800 Oak Grove Dr., T-1166, Pasadena, CA 91109.

June 17-22
ALCON '85, Tucson, Arizona. Contact: Shelley Fleischman, c/o Venture Travel Inc., 6709 E. Camino Principal, Tucson, AZ 85715.

June 22-27
97th Annual Meeting of the Astronomical Society of the Pacific, Northern Arizona University, Flagstaff, Arizona. Contact: Andrew Fraknoi, Summer Meeting, A.S.P., 1290 - 24th Ave., San Francisco, CA 94122. Phone (415) 661-8660.

June 28-30
IAPPP Summer Workshop, Flagstaff, Arizona. Contact: Robert Fried, Braeside Observatory, P.O. Box 906, Flagstaff, AZ 86002. Phone (602) 774-1249.

June 28-July 1
Royal Astronomical Society of Canada General Assembly, Edmonton, Alberta, Canada. Contact: RASC, Edmonton Centre, c/o Edmonton Space Sciences Centre, 11211 - 142 St., Edmonton, Alberta, Canada T5M 4A1.

July 11-14
The Study of Variable Stars Using Small Telescopes (symposium), University of Toronto, Toronto, Ontario. Contact: Dr. John R. Percy, Department of Astronomy, University of Toronto, Toronto, Ontario, Canada M5S 1A1.

July 12-14
The Convention of the Mid-States Region of the Astronomical League, Wichita, Kansas. Contact: Mike Kittrell, c/o Crown Products Inc., 310 N. Wabash, Wichita, KS 67214. Phone (316) 267-1051 days or (316) 524-8392 evenings.

July 15-20
Spaceweek UPstate 85, Haywood Mall, Greenville, South Carolina. Contact: PAS, P.O. Box 197, Fair Play, SC 29643-0197.

July 15-24
International Space Week '85, Cocoa, Florida. Contact: James B. Harris, Jr., Director, Florida Spaceweek Committee, 993 Macco Rd., Cocoa, FL 32927.

July 15-August 2
Astronomy Institute for Pre-College Teachers, The University of Texas at Austin, Austin, Texas. Contact: Mary Kay Hemenway, College of Natural Sciences, The University of Texas at Austin, Astronomy Department, RLM 15.308, Austin, TX 78712. Phone (512) 471-4461 ext. 307.

July 22-26
1985 Summer Institute, sponsored by Spitz Space Systems, Inc. Contact: Mona E. Coldiron, 1985 Summer Institute, Spitz Space Systems, Inc., P.O. Box 198, Chadds Ford, PA 19317.

August 9-11
STARFEST '85, The River Place Campground, Mount Forest, Ontario, Canada. Contact: Andreas Gada, 145 St. George St., Apt. 701, Toronto, Ontario, Canada M5R 2M1

August 15-19
Second Annual Mt. Kobau Star Party, Okanagan Valley, British Columbia, Canada. Contact: Peter Kuzel, 4100 25th Ave., Vernon, British Columbia, Canada V1T 1P4.

August 17
Stellafane, Springfield, Vermont. Contact: Dennis di Cicco, 60 Victoria Rd., Sudbury, MA 01776.

Meeting notices to appear in AstroCalendar must be submitted at least four months in advance of the meeting date. Most organizations appreciate your enclosing a long (business-size) self-addressed, stamped envelope along with your request for information.

ASTROMART

WANTED — Telescope to rent with larger than 2" mirror. Contact Claudio Moreira dos Santos, R. Agueda Goncalves — 240 — PD, Taboao da Serra, Sao Paulo, Brazil.

WANTED — Contact with clubs or observers in the Richmond-Petersburg, VA area. I am new to the area and would like to learn of observing sites. Contact Dave Donahue, 1749 S. Sycamore St., Petersburg, VA 23805. Phone (804) 732-5584.

WANTED — Compenents to build an 8" scope including diagonal, mirrors/mounts, spider, 1½" eyepiece mount, camera adapter, dust covers, end rings, eyepieces, filters, finderscope/mount, and setting circles. Contact W.G. Olson, 505 — 4th Ave., Asbury Park, NJ 07712. Phone (201) 988-8885.

WANTED — *Sky & Telescope*, August 1982. Will swap for either October 1981, May 1984, August 1984, or all three. Issues sent airmail (anywhere) to first reply received. Contact T. MacLeod, 48 Weldene Ave., Glenfield, Auckland, 10, New Zealand.

WANTED — Alt-azimuth mount for 2" refractor. Contact Bruce Smith, 3223 14th Ave. So., #9, Minneapolis, MN 55407. Phone (612) 722-5034.

EDITORIAL POSITION AVAILABLE

We are seeking an experienced individual for an editorial position with ASTRONOMY Magazine. The person we hire will have:

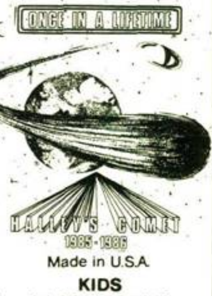
1. The ability to organize ideas, edit, and write about astronomy both as a hobby and as a science.
2. A solid working knowledge of modern astronomy.
3. Substantial accomplishments as an amateur astronomer.
4. A willingness to function as an integral part of the ASTRONOMY staff.

Send applications — with samples of what you have done — to:

Richard Berry, Editor-in-Chief
ASTRONOMY Magazine
P.O. Box 92788, Milwaukee, WI 53202

All applications will be treated in strictest confidence.

Halley's Comet T-Shirt



Top quality navy blue shirt with a four color design.

$10.50 each ppd.

Colo. Tax - $.32 per shirt
Colo. & RTD - $.38 per shirt

Made in U.S.A.

KIDS
2-4, 6-8, 10-12, 14-16
ADULTS
30-36, 38-40, 42-44, 46-48

Send check or money order to:

R B P
2000 W. 92nd Ave. #56
P.O. Box 211208
Denver, CO 80221

WANTED — Meteor photographers for the Upsilon Pegasid meteor shower. For free instructions, please send SASE to Florida Fireball Patrol, c/o Hal Provenmire, 215 Osage Dr., Indian Harbour Beach, FL 32937.

WANTED — Information on short-wave radios or astronomy programs for Commodore 64 computer. Contact Dolph Stamm, 78 Ashley Hall Plant, Apt. D-32, Charleston, SC 29407.

WANTED — Information about antique Bardou telescopes to help me learn the possible age and origin of my 3" Bardou refractor. Contact Steve Suo, 9893 Forest Glen Dr., Cincinnati, OH 45242.

WANTED — Designs, drawings, diagrams, information, and plans for disk drives, modems, printers, and anything else concerning computers or electronics. Contact Bob Bumpus, R.R. #2, Box 50, West Union, IL 62477.

WANTED — Amherst College math major seeks laboratory internship with scientist in NY, NJ, CT, MA, FLA, AZ, or CA. Resume/interview on request. Please contact Kira Bacal Serchuk, P.O. Box 1668, Amherst College, Amherst, MA 01002.

WANTED — Off-axis tracker, illuminated reticle eyepiece, and Questar Powerguide for Questar 7. Contact Charles E. Blumsack, 36 Commerce Way, Woburn, MA 01801. Phone (617) 935-3500.

WANTED — Correspondence about hypersensitization of film, construction of hypersentization chamber, and deep-sky photographic techniques. Contact Thomas Gadd, 3, Coastguard Cottage, Studd Hill, Herne Bay, Kent, England CT6 8BD.

WANTED — Correspondence with persons in the fields of geology/astronomy. I'm a college student in need of guidance in planning a planetary sciences major. Any assistance will be greatly appreciated. Contact Andrea Gianopoulos, P.O. Box 3052, Oshkosh, WI 54903.

LOOK WHAT'S ON THE SKY NOW...
FOR COMMODORE 64 $39.95
••PLANETARIUM (DISK)••

Draw positions of planets and constellations for any date and time (Bi-lingual programs).

Add $3 for shipping. Florida residents add 6% tax. International 15%. Specify English or Spanish. Enclose Money Order.

Interesting Software, P.O. Box 41-5012, Miami Beach, FL 33141

NEW ZEALAND

HALLEY'S WATCH

See New Zealand as guests of Astronomical Societies of NZ. Including all air and land arrangements from only $1365. 7-14 day itineraries for Halley's Comet Watch 1985/6. Call Rainbow Adventure Holidays for complete brochure.

US 800-722-2288
CA 800-227-5317

Add STS-51C to Your Emblem Collection

TOP SECRET

We can't tell you anything about this Defense Department Shuttle mission, but here's the patch!

STS-51C 4" x 4¾" $4.95

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

MIBRO CO., INC.
EST. 1950

CAMERA DISCOUNTS
ON ALL YOUR PHOTOGRAPHIC NEEDS

OUR ONLY STORE

MIBRO CO., INC.
1595 BROADWAY
(BETWEEN 48th & 49th STREETS)
NEW YORK CITY, NEW YORK 10019
MONDAY THRU SATURDAY 9 AM — 9 PM
SUNDAY 11 AM — 7 PM

Meade®

97D/3.5". SPOTTING SCOPE

INCLUDES: Diagonal Prism
• 2 Eye Pcs. • Tripod
• Adapter

CALL FOR NEW LOW PRICE

Meade 87D/3.1"	$199
Meade 2044/4" Schmidt-Cassegrain	$599

Meade Deep Space Telescopes DS-10/DS-16

IN STOCK • GREATLY DISCOUNTED

Meade®

1000mm F12.5 TELEPHOTO MIRROR LENS $199

1000mm/11.0	$279
1000mm/10.0	$379
2000mm/10.0	
8" Spotting Scope	$599
Spotting Scope Kit	$59

ALL ACCESSORIES IN STOCK

Meade®

107D/4" SPOTTING SCOPE

INCLUDES: Diagonal Prism
• 2 Eye Pcs. • Tripod
• Adapter

CALL FOR NEW LOW PRICE

Meade 2120/2120Lx3 10" Schmidt-Cassegrain Telescopes
IN STOCK • GREATLY DISCOUNTED

Bushnell

SPACEMASTER TELESCOPE

$119

ALL EYEPIECES IN STOCK
15 — 45x ZOOM — 60x — 40x
25x — 20x — 22x — WIDE ANGLE

CELESTRON

C-90 SPOTTING SCOPE

CALL FOR NEW LOW PRICE

C-90 ASTRO SCOPE
IN STOCK GREATLY REDUCED

ALL ACCESSORIES IN STOCK

BAUSCH & LOMB

CRITERION 4000 TELESCOPE

CALL FOR NEW LOW PRICE

CRITERION 4000 TELEPHOTO LENS	$239
CRITERION 6000	$699
CRITERION 8000	$799

WE CARRY A FULL LINE OF 35mm SLR CAMERAS • LENSES AND ACCESSORIES

Meade®

8" MODEL 2080 SCHMIDT CASSEGRAIN TELESCOPE

CALL FOR NEW LOW PRICE

Meade 2080 Lx/2080 Lx2/2080 Lx3
8" Schmidt Cassegrain
Telescopes in Stock
Greatly Discounted

CELESTRON

SUPER C-8
PLUS SCHMIDT CASSEGRAIN TELESCOPE
IN STOCK GREATLY DISCOUNTED

Also Available: Super C-8 Plus Starbrite • Super Polaris C-8 • Super Polaris C-80 Starbrite • C-11 & C-14 Telescopes

CELESTRON

C-80 REFRACTING TELESCOPE

$429

Firstscope 80	$399
Superpolaris SP-C80	$549
Sky Sensor	$349
C-80F Fluorite	$1,099
C-102 Refracting	$599
Superpolaris SP-C102	$799

CELESTRON

C-6 NEWTONIAN REFLECTOR

$529

COMET CATCHER	$259
COMET CATCHER EQUATORIAL MOUNT	$329
COMET WATCHER	$99
COMET CATCHER JR.	$199

ALL ACCESSORIES IN STOCK

BAUSCH & LOMB

DISCOVERER
ZOOM 15 - 60x
POWER TELESCOPE

$187 ADAPTS TO ALL 35mm CAMERAS TO BECOME 1000-4000mm TELE./ZOOM

HARBORMASTER TELESCOPE IN STOCK GREATLY DISCOUNTED!!

Meade®

2.4" ALTAZIMUTH REFRACTING TELESCOPE

$129

CELESTRON-COMETRON 40	$59
CELESTRON-COMETRON 60	$99
DELUXE COMETRON 60	$179

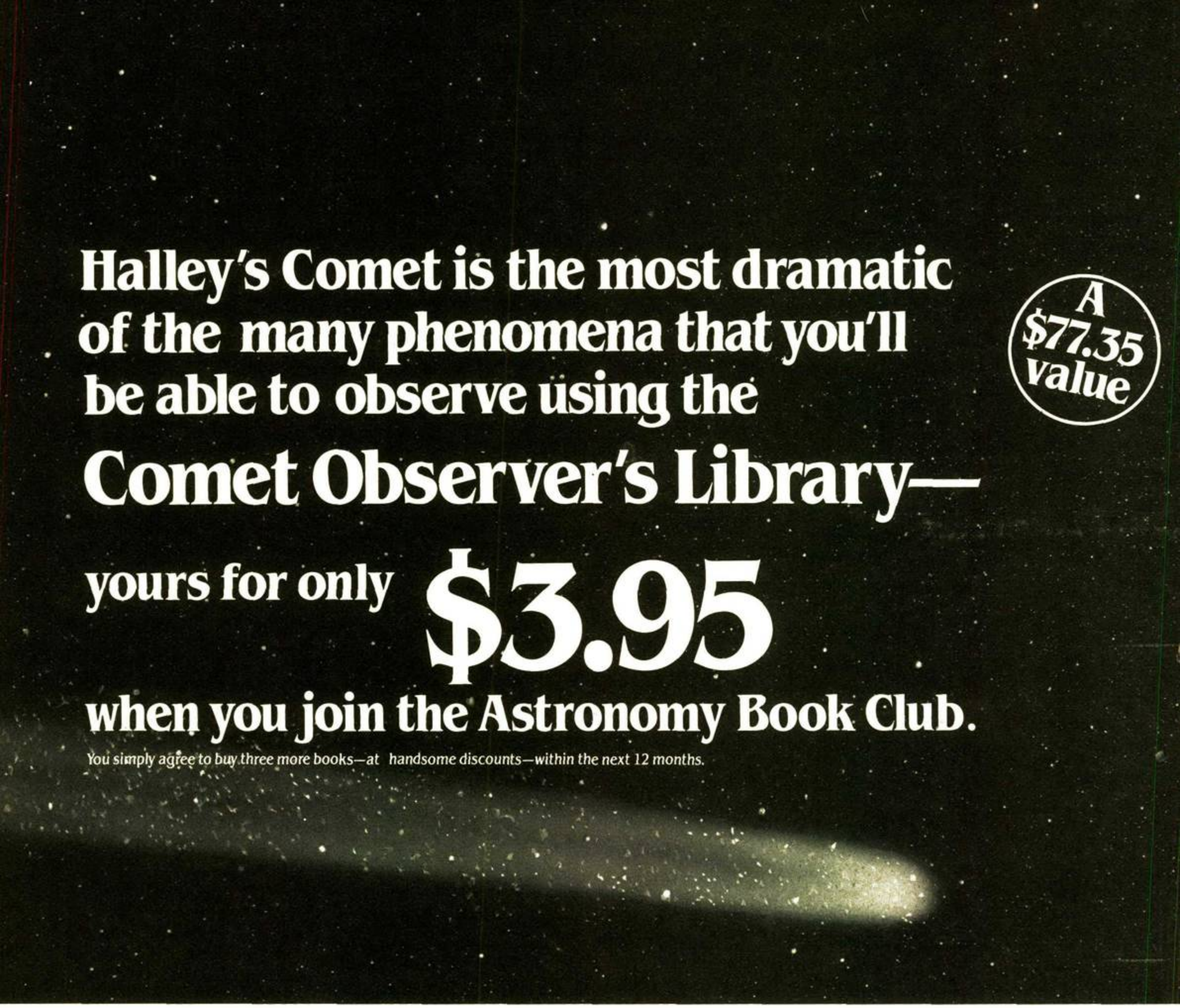
ORDER NOW!

FOR PHONE ORDERS ONLY
CALL TOLL FREE

1 • 800 • 223 • 0322

NEW YORK RESIDENTS CALL
(212) 757-6688 (212) 582-4294
WE ACCEPT ALL MAJOR CREDIT CARDS
ON ALL PHONE ORDERS CALL
MONDAY — SATURDAY 9:30 AM - 9:00 PM
SUNDAY 11 AM - 7 PM

All Merchandise Brand New. Factory Fresh. Minimum Shipping & Handling Charge $7.95. Quantities May Be Limited on Some Items — Refunds Within 7 Days With Original Packaging And Unfilled Guarantee Card. Please Call Before Sending Any Money Orders. Some Acc. May Be Add. From Original Packaging. Not Responsible For Typographical Errors. Some Items Add. For Warranty in U.S.A. For Customer Service Please Call 12:30 pm - 6:30 pm. Prices Subject To MFG. Increase/Decrease. Pictures for illustration purposes only.



Halley's Comet is the most dramatic of the many phenomena that you'll be able to observe using the

Comet Observer's Library—

yours for only $3.95

when you join the Astronomy Book Club.

You simply agree to buy three more books—at handsome discounts—within the next 12 months.

A $77.35 value

"A FLURRY OF RESEARCH ACTIVITY THAT IS WITHOUT PRECEDENT IN THE HISTORY OF COMETARY SCIENCE."

That's how authors Chapman and Brandt describe the preparations now underway for the return of Halley.

Halley's Comet is unique. It's the only comet whose appearances have been continually noted for over 2,000 years. It's the best-known comet in the world. And it's the only one whose coming can be prepared for with the full resources of modern technology.

1985-1986, then, promises to be a big year in astronomy.

And now you can be part of it when you join the Astronomy Book Club and take as your introductory offer—the Comet Observer's Library.

In this library you will discover...

INTERNATIONAL HALLEY WATCH AMATEUR OBSERVERS' MANUAL FOR SCIENTIFIC COMET STUDIES. *By Stephen J. Edberg.* A manual for the amateur astronomer who wants to participate in the gathering of useful data on Halley, with emphasis on skilled

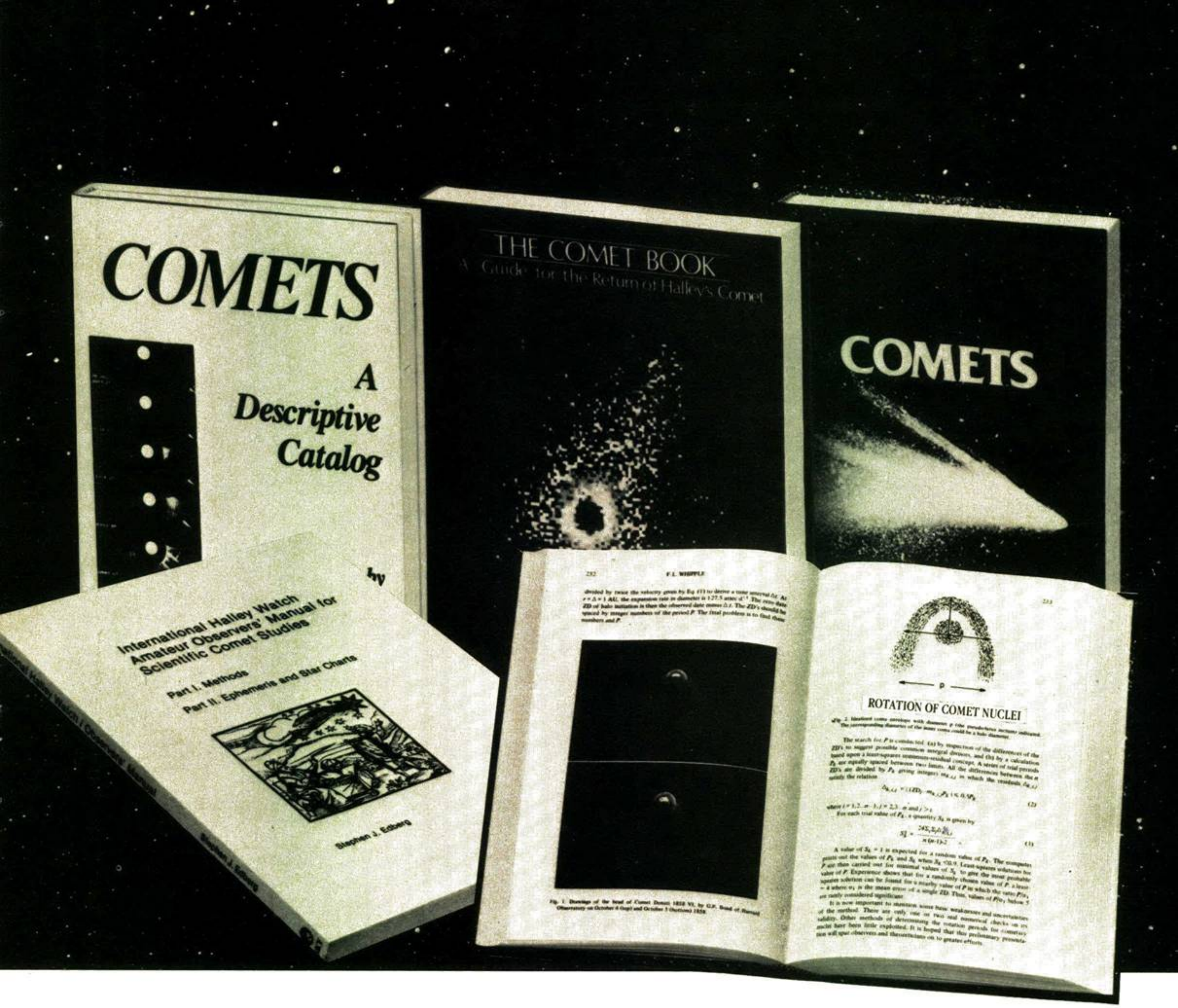
4 Good Reasons to Join

1. The Finest Books. Of hundreds and hundreds of books submitted to us each year, only the very finest are selected and offered. Moreover, our books are always of equal quality to publishers' editions, *never* economy editions.

2. Big Savings. In addition to getting the Comet Observer's Library for only $3.95 when you join, you keep saving substantially—up to 30% and occasionally even more. (For example, your total savings as a trial member—including this introductory offer—can easily be over 50%. That's like getting every other book free!)

3. Bonus Book. Also, you will immediately become eligible to participate in our Bonus Book Plan, with savings up to 70% off the publishers' prices.

4. Convenient Service. At 3–4 week intervals (16 times per year) you will receive the Astronomy Book Club News, describing the Main Selection and Alternate Selections, together with a dated reply card. If you want the Main Selection, do nothing and it will be sent to you automatically. If you prefer another selection, or no book *at all, simply* indicate your choice on the card, and return it by the date specified. You will have *at least* 10 days to decide. If, because of late mail delivery of the News, you should receive a book you do not want, we guarantee return postage.


COMETS
A Descriptive Catalog
by
THE COMET BOOK
A Guide for the Return of Halley's Comet
COMETS
International Halley Watch Amateur Observers' Manual for Scientific Comet Studies
Part I. Methods
Part II. Ephemeris and Star Charts
Stephen J. Edberg
F.L. WHIPPLE
ROTATION OF COMET NUCLEI

scientific observing. Covers how to observe, what to observe, what materials are needed, how to report data, along with detailed authorized report forms to be sent to the Jet Propulsion Laboratory. 192 pages. Publisher's price: $9.95.

COMETS: A Descriptive Catalog. *By Gary W. Kronk.* A new "cometography," this volume presents a detailed compilation of the discoveries and subsequent observations of every comet from 371 B.C. to the present. This invaluable reference covers over 500 long period comets and 120 short period comets, plus 138 "unconfirmed" comets. 340 pages. Publisher's price: $22.50.

THE COMET BOOK: A Guide for the Return of Halley's Comet. *By Robert D. Chapman and John C. Brandt.* An immensely readable account of comets, their history and folklore, bridging into the modern era and the great work of Kepler and Tycho Brahe. A comprehensive, but easy-to-read, description of the origin and physical processes of comets. The book details both the 1985-1986 appearance of Halley and the plans for its study. Profusely illustrated with 64 photos, 38 charts and graphs, plus an additional 8 pages of stunning color plates. 175 pages. Publisher's price: $14.95.

COMETS. *Edited by Laurel B. Wilkening, with 48 collaborating authors.* This is an up-to-date collection of technical articles in various aspects of cometary science by a number of well-known researchers in the field. Its 766 pages are profusely illustrated with charts, diagrams, and tables. Subjects include: Dynamics of Plasma Tails, Chemical Composition of Nuclei, Cometary Plasma Processes, Ultra-violet Spectroscopy of Comae, and much more. Publisher's price: $29.95.

Astronomy Book Club is operated exclusively for astronomy enthusiasts. The club is devoted to making the finest astronomy books available conveniently and inexpensively. Recent offerings have included titles by such eminent authorities as Patrick Moore, Robert Jastrow, John Gribbin and George Abell.

If reply card has been removed, please write to: Astronomy Book Club, Dept. L-BF4-00605, Riverside, N.J. 08075 to obtain membership information and an application.

Astronomy 5/85

For Visa or MASTERCARD
Order Dial Toll Free
(Orders Only)
800-223-6119

New York Camera

SPECIAL 40% OFF ALL ACCESSORIES

Meade®

THE LEADER'S EDGE
**Lifetime Warranty*

FREE CAMERA WITH PURCHASE

8" MODEL 2080/LX3*

Schmidt-Cassegrain Telescope complete with all accessories as supplied by the manufacturer. Including Quartz Electronic LX Drive System and Remote Control with field tripod & wedge. Operates AC or DC without any converters! **1499**

10" Model 2120/LX3* .... **CALL**
8" Model 2080/LX2* **1180**
(w/LX Drive System & High Transmission Coating)
8" Model 2080* .... **IN STOCK**
4" Model 2045 Schmidt-Cassegrain* **645**
(w/Motor Drive, Table Tripod & Case)
6" Newtonian Reflector Model 6600 with German Equat Mt 900mm f6 with USA made PYREX OPTICS .... **.659**
8" Newtonian Reflector Model 8800 same as 6600 + large f4.5 aperature **859**

TELEPHOTO LENSES		**SPOTTING SCOPES**	
Model 80 1000mm f12.5	**CALL**	87D 3.1"	**CALL**
90B 1000mm f11	**298**	97D 3.5"	**339**
102 1000mm f10	**365**	107D 4"	**395**

Model 2081 2000mm f10 Schmidt-Cassegrain Spotting Scope Complete outfit w/Eye Pieces, Finderscope, Covers and Case **650**

Refracting Telescopes
Model 226 2.4" Complete w/Tripod **129**
Model 291 2.4" Equatorial w/Tripod **269**
Model 300 3.1" Equatorial w/Tripod **475**

Call for low prices on Meade Research and Deep Space Telescope Camera Adapters for all Telescopes in stock
We carry all Meade Eye Piece Accessories.

PHOTOGRAPHIC OUTFITS—FOR ALL TELESCOPES

- **BASIC KIT** • 35mm Reflex Camera • "T" Mount • Wide Strap • Monopod w/Carry Strap **99.95**
- **ADVANCED KIT** • 35mm Reflex Camera • "T" Mount • Wide Strap • Deluxe Tripod **129.95**
- **DELUXE KITS** • Your Choice
- 50/1.7 Add **24.95**
- 35mm or 135mm ..**19.95**
- 35-70 Zoom Add.. **59.95**
- 28-80 Zoom Add.. **79.95**
- 35-105 Zoom Add **79.95**
- 35-200 Zoom Add **139.95**
- 80-200 Zoom Add **49.95**
- 70-210 Zoom Add **79.95**

*** IN STOCK ***
MINOLTA MAXXUM

- World's only SLR with Built-in Auto-focus.
- World's Easiest SLR System
- 2 Yr. Minolta USA Limited Warranty

New York Camera Carries All Major Photographic, Video, Electronics, Typewriters and Copiers
Call for low prices.

Some telescopes may have limited availability.
Consumer Affairs #800831

New York Camera

131 W. 35th St. New York City, N.Y.

212-564-4398
800-223-6119
OPPOSITE MACY'S

Telex 971877
Hours: Mon-Fri 9-7
Sun 10-5

SEND CERTIFIED CHECK OR MONEY ORDER FOR IMMEDIATE SHIPMENTS PLEASE ALLOW 30 DAYS FOR BANK CLEARANCE ON PERSONAL CHECKS SHIPPING & HANDLING NONREFUNDABLE NOT RESPONSIBLE FOR TYPOGRAPHICAL ERRORS OUR ONLY LCOATION 131 W. 35th St OPPOSITE MACY'S U.S. DIST. WARR MAY BE HIGHER

FOR TECHNICAL INFORMATION PLEASE CALL (212) 695-0697 "ALL ITEMS ARE COMPLETE WITH ALL ACCESSORIES AS SUPPLIED BY MANUFACTURER"

CELESTRON®

PRECISION OPTICS *25 year warranty

SUPER C8 PLUS*

Schmidt-Cassegrain Telescope Complete with all Accessories as supplied by the Manufacturer including 7" Byers Worm Gear Drive **989.00**

Special Outfit including Celestron Adjustable Tripod and C5/8 Wedge .... **CALL**
Super Polaris C8 including New Super Polaris Equatorial Mount and Tripod **715**
Sky Sensor Computer and Stepping Motor for Super Polaris Mounts **395**
C5 Telescope **750**
C5 With Special Coating **830**
C90 Astro Telescope* With Elec Clock Dr & Fork Mt .**CALL**
C6 Newtonian Reflector* with Tripod **547**
C80 Refractor* Complete outfit with Equatorial Mount and Tripod **450**
C80 Super Polaris Outfit............................ **548**

Special: First Scope 80
The Perfect Beginners Telescope **329**

Comet Catcher*F3.64 Compact Size/330 X MAG **265**

Cometron Telescopes by Celestron

Comet Watcher	**95**	Cometron 40	**76**
Sky Watcher	**175**	Cometron 60 White	**129**
Sky Scanner	**240**	Deluxe 60	**210**
Comet Catcher JR	**195**	**C90 Spotting Scope**	**309**

*15-60X Rubber Coated Spotting Scope **205**

GIANT BINOCULARS*
Complete w/Case and Tripod Adapter

11 x 80	**228**	20 x 80	**239**
30 x 80	**249**	Deluxe 20 x 80	**369**

Solar Filters for all Celestron IN STOCK
Call for Low Prices on Celestron C-11 and C-14 Telescopes
We carry All Celestron Accessories
Celestron Sky Maps **14**
DC CONVERTER C/90/5/8/11 **98**

OSRAM		**ZEISS**		**NIKON**	
Diastar	**88.95**	Mini Binocular 8x20 IF	**196.95**	9x30 w/Case	**163.95**
Diastar 251A	**119.95**	Mini Binoc 8x20 BCF	**187.95**	12x40 w/case	**176.95**
Video Light S1000	**49.95**	Mini Binoc 10x25 BCF	**217.95**	8x30 DIF Rubber	**148.95**
LEITZ		Dialyt 8 x30 B/GA IF	**344.95**	7x35 E w/Case	**108.95**
		Dialyt 8x30 B/GA CF	**439.95**	8x30 E w/Case	**125.95**
7x42B **467.95**	8x40B **443.95**	Dialyt 8x30 B/CF	**406.95**	7x20 CF **47.95** 9x25 CF	**52.95**
8x32B **413.95**	10x40B **457.95**	Dialyt 10x40 B/CF	**484.95**	7x50 CF HP w/Case	**172.95**
8x40BA **499.95**	10x40BA **519.95**	Dialyt 10x40 B/GA CF	**509.95**	7x50 BIF HP Rtcl	**220.95**

LEICA TRINOVID BINOCULARS SPECIAL
- 8 x 20 BCA Compact Armoured **174**
- 10 x 25 BCA Compact Armoured **189**

Color Print Film

Kodak		ASA	With Out Proc.	With Kodak Proc.
CP	135-24	100	**2.00**	**8.40**
CP	135-36	100	**2.50**	**11.69**
CL	135-24	200	**2.29**	**8.79**
CL	136-36	200	**2.80**	**11.99**
CM	135-24	400	**2.59**	**9.09**
CM	135-36	400	**3.15**	**12.34**
CF	135.24	1000	**3.29**	**9.79**
CF	135-36	1000	**3.99**	**13.18**
VPS	135-20	160	**2.49**	**8.79**
VPS	135-36	160	**3.25**	**12.78**

Color Slide Film

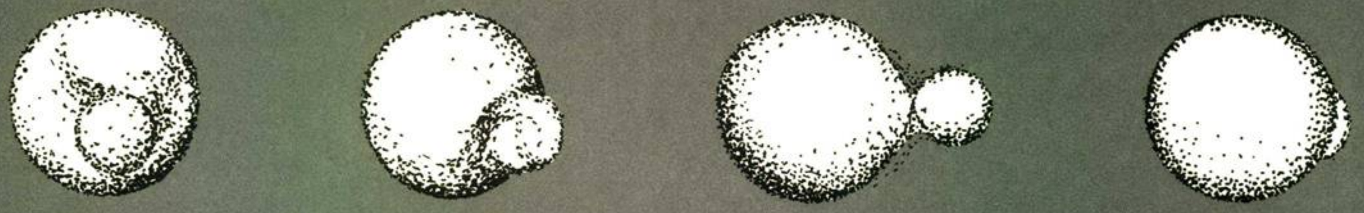
	Kodak	ASA	With Out Proc.	With Kodak Proc
KM	135-36	25	**3.99**	**5.89**
KR	135-20	64	**2.85**	**5.14**
KR	135-36	64	**3.83**	**5.89**
EN	135-36	100	**3.65**	**7.24**
ET	135-36	160	**5.19**	**8.79**
ED	135-20	200	**3.85**	**6.14**
ED	135-36	200	**4.40**	**7.99**
EL	135-20	400	**4.29**	**6.58**
EL	135-36	400	**4.99**	**8.59**

NEW AGFA PROFESSIONAL SLIDE & PRINT FILMS IN STOCK IN 35mm & 120

50% OFF HOYA FILTERS

Cokin
Creative Filter System
ALL FILTERS 50%
OFF COKIN LIST PRICE

Video Camera Adaptors for All Meade & Celestron Scopes **29**



When Stars Coalesce

by Ken Croswell

Our Sun is unusual in its solitude; most stars prefer to journey through the Galaxy with a partner or two. Stars can form unions with one, two, three, or even more companions, but by far the most common stellar marriage is the binary — a system of two stars in orbit about one another, held together by their mutual gravity.

Binary systems are extremely diverse. In *detached binaries*, hundreds of billions of kilometers separate the two stars — light traveling from one star takes several weeks to reach its distant neighbor. Other stars get much closer to their mates, forming *close binaries* in which material flows from one star to the other. The most bizarre binaries, though, are *contact binaries*, in which two stars actually touch each other and share a common atmosphere. Although contact binaries sound exotic, the Galaxy is full of them: the nearest — 44 Bootis B — lies less than 40 light-years away (see "Contact Binaries: Stars That Touch," ASTRONOMY, December 1982).

Until recently, astronomers thought that contact binaries were the most extreme case possible. But in the last four years, astronomers have uncovered an entirely new class of object: binaries that have actually *coalesced* into single stars.

Although these unusual objects have attracted attention only recently, their story began in 1948 when astronomer Paul Merrill reported on a strange eighth-magnitude star in the constellation Coma Berenices. Known as HD 117555, the star is a G-type giant rotating at an incredibly high speed. Astronomers can't measure a star's actual rotational speed, but they can measure a quantity called V sin I — the star's rotational velocity as altered by its orientation to us. Pronounced "vee-sine-eye", it means nothing more than the rotational velocity times the sine of the inclination angle of the star. Because we don't know the inclination, V sin I represents the lower limit of the star's rotation speed (see box on page 70).

Merrill measured HD 117555's V sin I as 75 kilometers per second; for comparison, our Sun spins at the leisurely rate of 2 km/sec. Since the star's spectrum revealed bright hydrogen emission lines, Merrill suggested the star's rapid rotation creates a centrifugal force that flings material off its equator. This material, he argued, could form a warm ring around the star and produce the observed hydrogen emission.

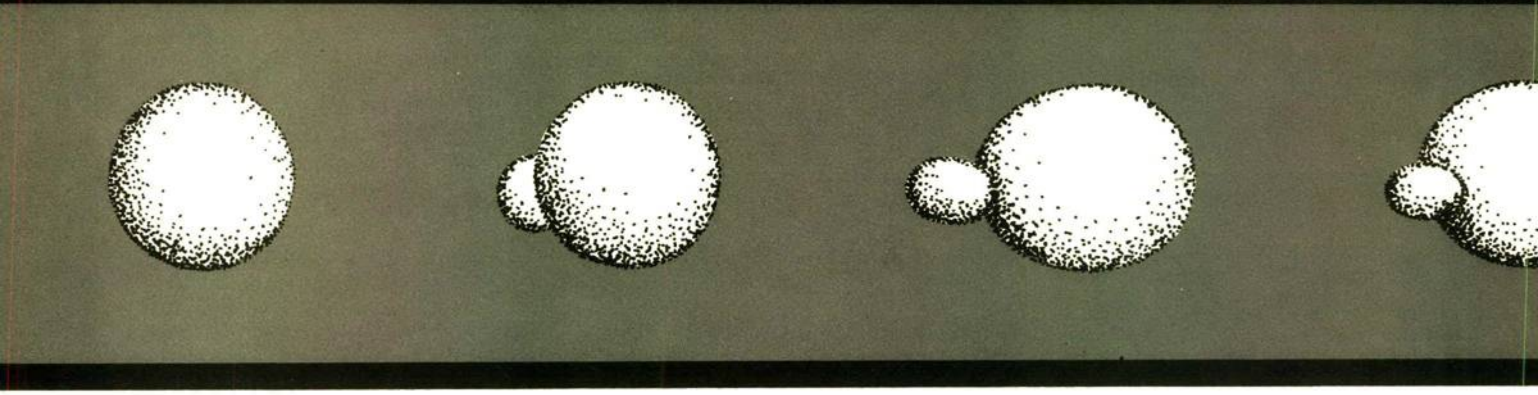
Merrill's odd star also showed strong emission lines of singly-ionized calcium (Ca II) — calcium atoms missing just one electron. Astronomers frequently use Ca II emission as an indicator of chromospheric activity, such as stellar flares, so HD 117555's strong Ca II emission suggests a very active chromosphere — not surprising for such a fast-spinning star.

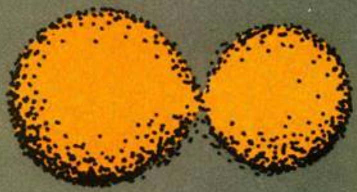
But why does HD 117555 rotate so fast? Since late-type giants evolve from compact main-sequence stars like the Sun, they should spin slowly. Even if a main-sequence star rotates rapidly, most of its spin is lost when it expands into a red giant — the same way a spinning ice skater slows upon extending his arms. Most late-type giants rotate at less than 10 km/sec, but a few spin as fast as 40 or 50 km/sec. These fast-spinning giants are usually members of close binary systems. The companion pulls on the giant star, forcing it to rotate as fast as the companion orbits. In these systems, the companion has "spun up" the giant until the two stars are synchronous — that is, until their orbital periods and rotation periods are equal so that each star always presents the same side to its companion. One entire group of variable stars — the RS Canum Venaticorum class — consists of giant stars spun up by their companions. Their rapid spin induces strong magnetic fields which, in turn, cause huge starspots. These starspots, cool dark regions on a star's surface similar to sunspots, periodically vary the star's brightness as they rotate in and out of view. But in 1948, Merrill could find no evidence of HD 117555's companion.

In 1966, Russian astronomer P.F. Chugainov discovered that HD 117555 is variable. Astronomers record a newly found variable by giving it a new name, one consisting of a combination of letters followed by the possessive form of its constellation name. After Chugainov's discovery, astronomers rechristened the mysterious star FK Comae Berenices. Chugainov reported that FK Comae varies by a tenth of a magnitude with a period of 2.4 days.

Eight years later, on a cloudy night at Kitt Peak National Observatory, Bernard Bopp was leafing through an old astronomical journal and came across Merrill's 1948 report concerning FK Comae. A rapidly rotating G giant? Outlandish, thought Bopp; the star must really be a main-sequence star that's been misclassified as a giant. But subsequent studies confirmed FK Comae's giant status.

At that time, Bopp and his colleagues were studying a dozen orange and red dwarfs, which happened to include the K-type star UZ Librae. In the course of their investigation, Bopp realized UZ Librae was not a dwarf but a giant. Yet the star was rotating very fast — at least 50 km/sec — despite its great size. FK Comae

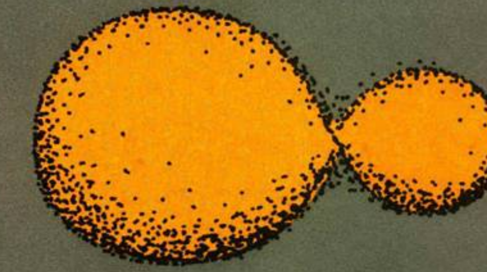




According to Ronald Webbink's 1976 scenario, after a contact binary first forms . . .

Mass: 1.11 Suns
Diameter: 1.0 Sun
Period: 7.7 hours

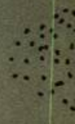
Mass: 0.74 Sun
Diameter: 0.8 Sun
Orbital Velocity: 230 km/sec

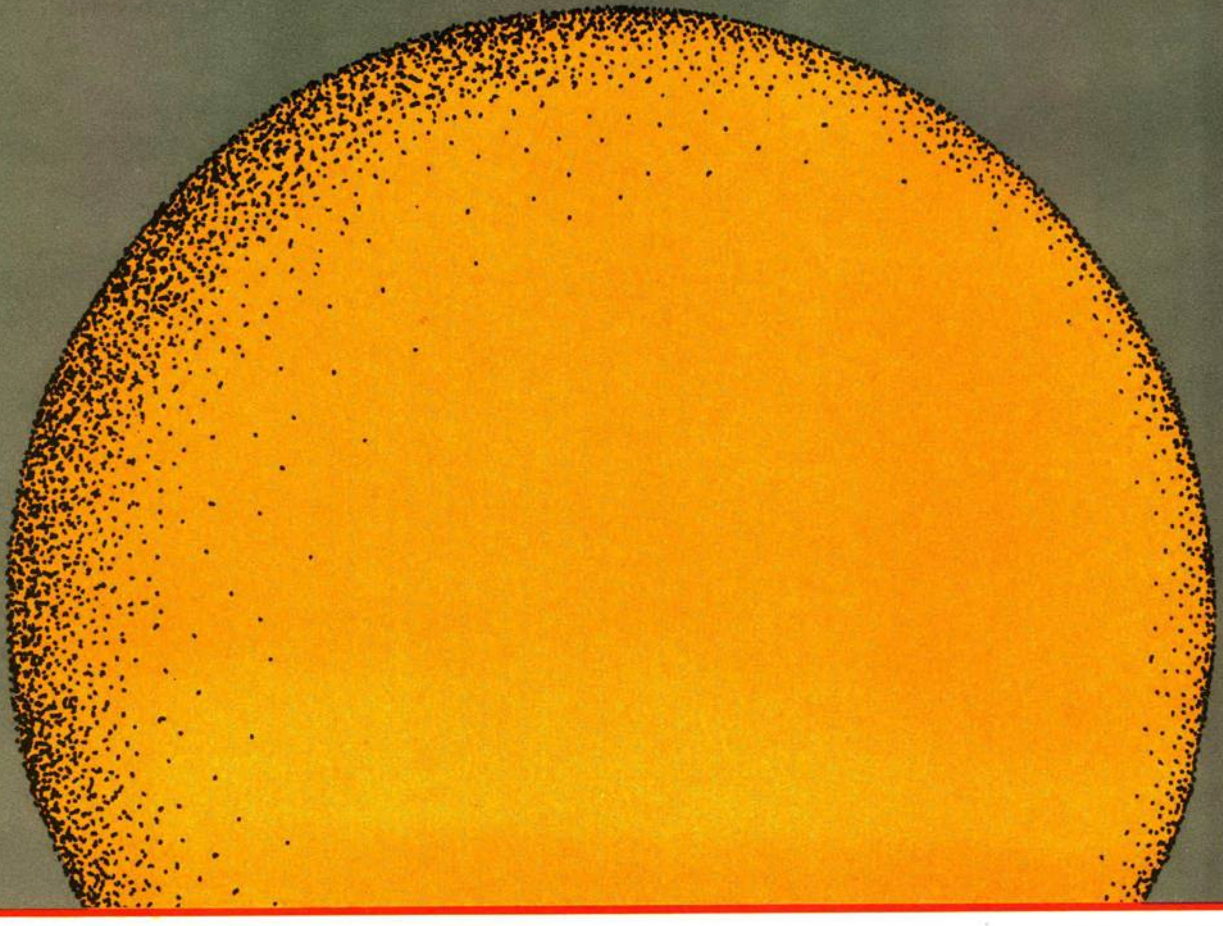


. . . the primary star gains mass by pulling material from its companion.

Mass: 1.52 Suns
Diameter: 1.7 Suns
Period: 14.2 hours

Mass: 0.33 Sun
Diameter: 0.9 Sun
Orbital Velocity: 260 km/se





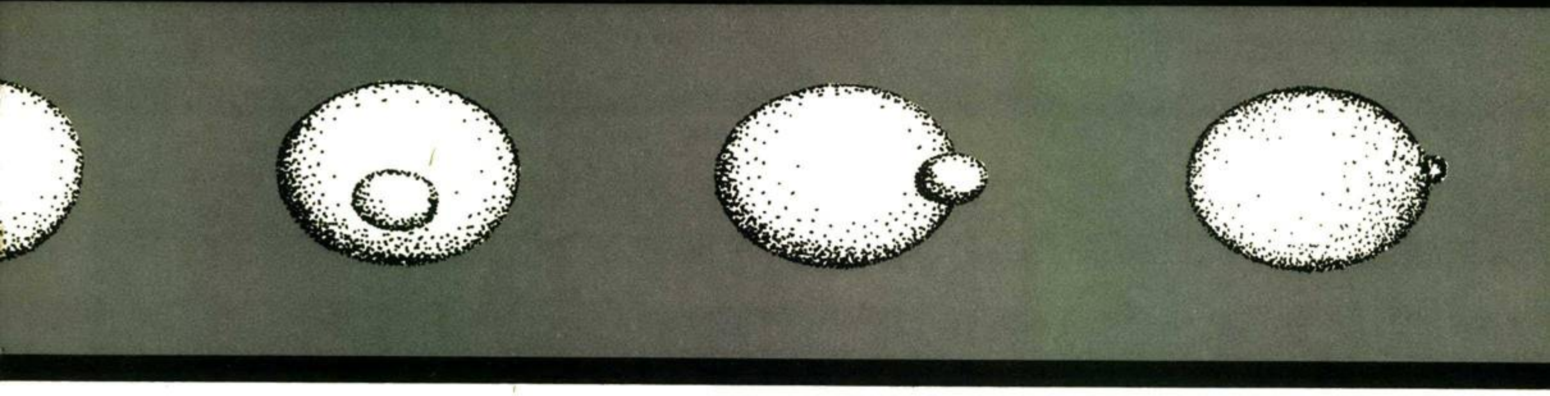
The

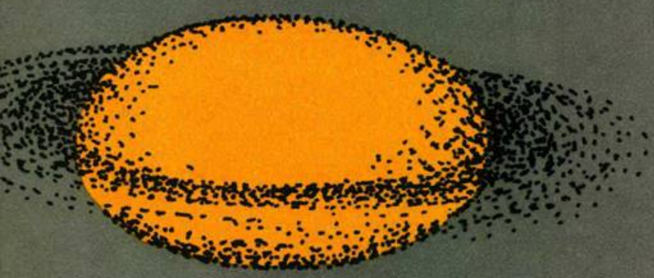
Rot

Ma

Dia

Per





When the primary star exhausts the hydrogen fuel in its core, it swells and engulfs its neighbor. The two stars merge into a single, rapidly rotating star. The star spins so fast that it throws off material near its equator, forming an "excretion disk" that girdles the star.

Period: 13.2 hours

Rotational Velocity: 225 km/sec

Mass: 1.85 Suns

Diameter: 2.4 Suns

-merged binary evolves into a giant star.

ional Velocity: 89 km/sec

1.85 Suns

ter: 6.7 Suns

: 91.2 hours (3.8 days)

The giant star eventually sheds its atmosphere, which forms an expanding shell of glowing gas around the star, and collapses into a tiny white dwarf.

Period: 1.2 minutes (0.02 hour)

Rotational Velocity: 692 km/sec

Mass: 0.71 Sun

Diameter: 0.01 Sun

clearly had a K-type twin.

Only one suggestion made sense — both stars are spinning fast because each has a companion that had spun it up. Stars in a binary system periodically move toward and away from us as they circle one another. This movement induces periodic blueshifts and redshifts in the spectral lines. Bopp looked for such spectral shifts but, as he examined spectrogram after spectrogram, could find none. FK Comae and UZ Librae seemed to be what couldn't be: fast-spinning single giants. Furthermore, Bopp's investigation turned up a *third* member of the class — HD 199178 — which other astronomers had labeled as a rapidly rotating G giant with strong Ca II emission.

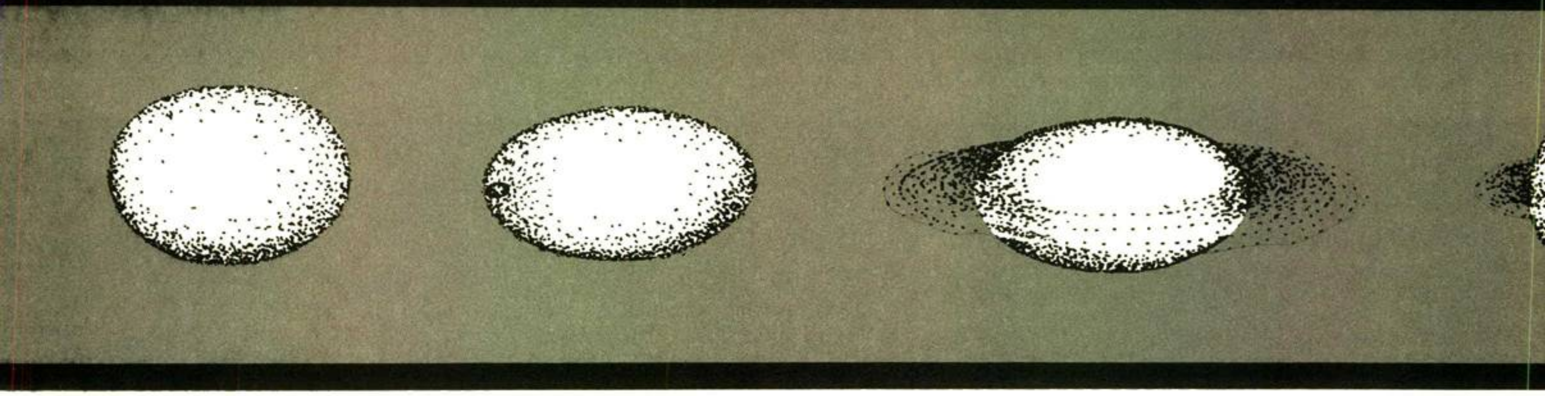
Bopp, now of the University of Toledo, joined Robert Stencel of the Joint Institute for Laboratory Astrophysics to study FK Comae stars in the ultraviolet. In 1981, they published observations made with the International Ultraviolet Explorer (IUE) satellite. The scientists focused their research on a few individual chemical elements — like magnesium (Mg). Magnesium is similar to calcium (both lie in the second column of the periodic table), and Mg II emission — like Ca II emission — is a hallmark of chromospheric activity in stellar atmospheres. Mg II's most important lines lie in the ultraviolet at 2796 and 2803 angstroms. Since Earth's atmosphere shields us from such short-wavelength radiation, only a rocket or satellite (such as IUE) can detect these lines.

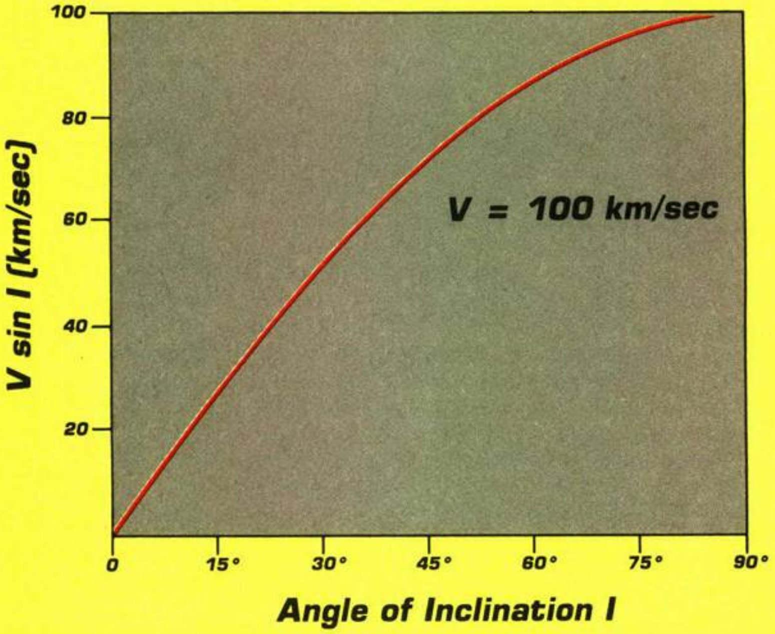
All three FK Comae stars showed very strong Mg II emission, indicating very active chromospheres. By measuring the width of the Mg II lines, Bopp and Stencel found that FK Comae was rotating the fastest: its V sin I was 120 km/sec — even greater than what Merrill had claimed in 1948. (The latest measurement, made in 1984, found a V sin I of 160 km/sec!) The stars didn't belong to the RS Canum Venaticorum class, for they rotated much faster than any of its members. More importantly, Bopp and Stencel could find no evidence for the cyclic Doppler shifts found in binary systems. Either the three FK Comae stars were single or they had companions of very low mass.

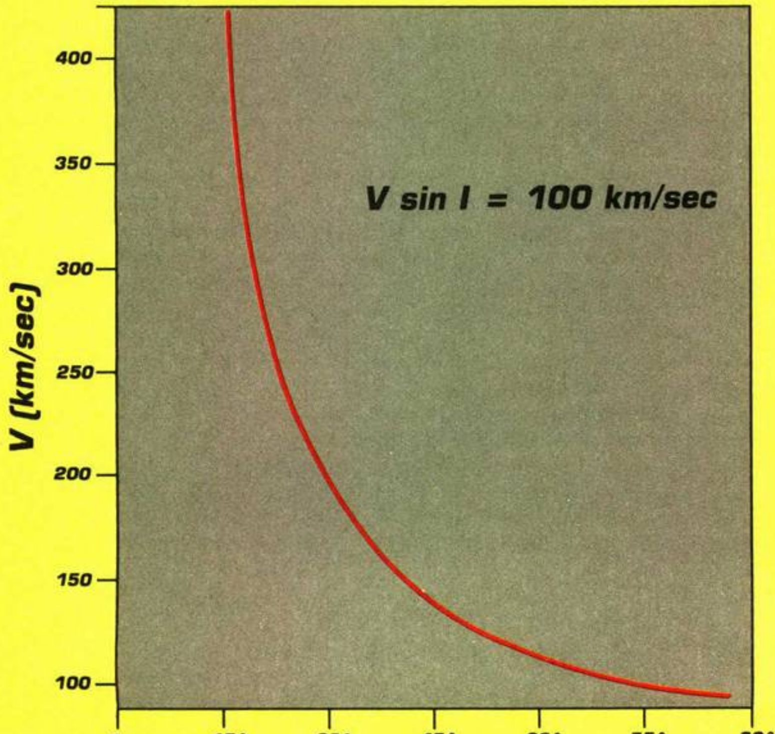
How did the FK Comae stars come to be? If they evolved from much smaller, single, main-sequence stars like the Sun, then they must have been rotating far faster than they do today. In fact, the stars would have been spinning so fast that they'd have flung themselves apart.

Bopp and Stencel made a novel proposal: FK Comae stars were contact binaries that had coalesced into single stars. It wasn't an unprecedented idea. In the mid-1970s, University of Illinois astronomer Ronald Webbink was studying contact binaries and how they might evolve. When a single star lies on the main sequence, it creates energy by turning the hydrogen in its core into helium; eventually the star's core runs out of hydrogen and the star swells into a red giant.

Webbink wondered what would happen when the more massive star in a contact binary exhausted the hydrogen in its core. His calculations showed that the massive star begins to expand into a giant even as it draws material from its companion. The stars spiral in toward one another. As orbital angular momentum changes to spin angular momentum, the two stars coalesce into a single, rapidly rotating star — surrounded,







Measuring a Star's V sin I

How do astronomers know FK Comae and its cohorts rotate so fast? The answer lies in the Doppler shift: one limb of a rotating star spins toward us, while the other limb spins away from us. Light from the star's approaching limb is shifted toward the blue end of the spectrum, and light from the receding edge becomes shifted toward the red end. This color change smears lines in the star's spectrum, broadening them. By measuring the width of these lines, we can learn something about the star's rotation.

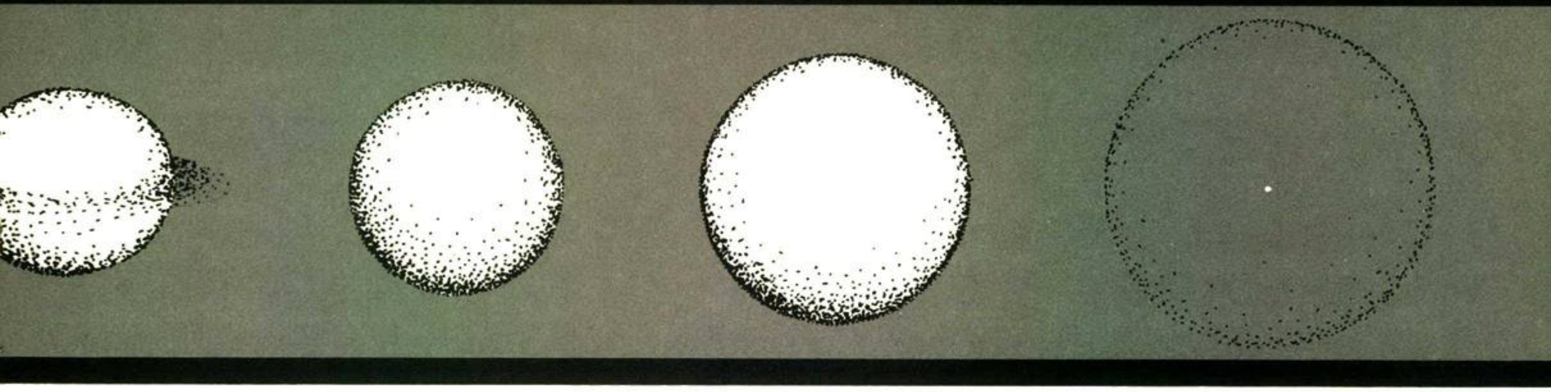
But we cannot deduce a star's *actual* rotation velocity (call it V); we can only determine its lower limit. To understand why, picture a fast-spinning star which we view pole on — that is, its rotational axis lies in our line of sight. Even if the star spins very fast, no part of the star approaches or recedes from us, so its spectral lines don't get rotationally broadened. No Doppler broadening means no clues to the star's rotational speed. In contrast, if we view a star with its equator in our line of sight, our spectrographs see the full force of its rotation, and the speed we measure is the star's true equatorial velocity.

Most stars lie between these two extremes. Astronomers define a star's angle of inclination (I) as the angle the star's rotation axis makes with our line of sight. For a star we view pole on, I = 0°; for one we see equator on, I = 90°; and for intermediate cases, I lies between 0° and 90°.

What astronomers really measure is the product of V times the sine of the inclination angle — V sin I. Since the sine of any angle is always less than or equal to one, V sin I can only *under*estimate the true rotational velocity of the star. Thus, when we say V sin I = 160 km/sec for FK Comae, we're really saying FK Comae's rotational velocity is *at least* 160 km/sec and could be much more, depending on the star's true inclination.

As an example, consider a star rotating at 100 km/sec. The top graph shows the V sin I you would measure for different inclinations. As you can see, only if I is near 90° do you come close to the truth.

One can, of course, reverse this. Suppose you measure a star's V sin I. What is the star's true V for a given angle of inclination? *The bottom graph* gives the answer for V sin I = 100 km/sec. Notice that if I is less than 30°, the actual rotational velocity is more than twice the measured quantity of V sin I!



Webbink said, by an "excretion disk" composed of material from the former binary. Webbink predicted that a coalesced binary would look like a late G-type giant star and rotate at around 100 km/sec. Webbink's hypothetical excretion disk, furthermore, could be the source of the hydrogen emission lines found in the FK Comae stars' spectra.

Bopp and Stencel's suggestion seems to vindicate the calculations Webbink made years before. But not all astronomers believe FK Comae is a coalesced binary. Because of uncertainties in the measurements, FK Comae could still have a very low mass companion which would induce only small variations in the spectral lines — variations too small to see. Fred Walter, now of the Joint Institute for Laboratory Astrophysics, and Gibor Basri of the University of California at Berkeley, suggested in 1982 that FK Comae does in fact have such a low-mass companion which pours its material onto the G giant. They claimed a bright hot spot forms where this stream of material flows onto the G star. As the small companion revolves about its giant partner, so does the hot spot, which accounts for the stars' periodic changes in brightness. Bopp had instead thought that dark starspots caused the variability of these stars.

According to the first estimates, the primary star had to be at least five times more massive than any companion. Walter and Basri suggested the giant had a mass of about 2.2 Suns, while that of the secondary was less than 0.4 solar mass. James McCarthy and Larry Ramsey of Pennsylvania State University recently made more precise measurements which tightened the constraints: the primary is now known to contain at least 20 and possibly as much as 40 times the mass of its neighbor. This forced Walter to raise the mass of the primary star to four Suns in order to keep the secondary's mass respectable (greater than one-tenth that of the Sun).

Two separate studies published in 1984 found that starspots — not bright spots — are the most likely cause of FK Comae's variability. In fact, David Dorren of the University of Pennsylvania and Ed Guinan of Villanova University found evidence that FK Comae not only has starspots, but also a spot *cycle* lasting a little more than a year. The Sun's spot cycle, in contrast, lasts 11 years.

If FK Comae really is a four solar mass star, it must be very young for such massive stars die less than a billion years after their birth. Young stars orbit the Galaxy tightly confined to the galactic plane — they make up the so-called young disk population. However, Dorren and Guinan's most recent computations indicate that FK Comae belongs to the *old* disk population and that it lies more than 600 light-years north of the galactic plane — unheard of for young stars. Therefore, it appears that FK Comae is an old star that could not have evolved from such a high-mass binary. In short, most astronomers now believe FK Comae has no stellar companion.

If FK Comae stars do indeed evolve from contact binaries, other FK Comae stars should exist as well. In 1982, two additional FK Comae stars — HD 32918 and HD 36705 — were discovered. Later that year, however, Slavek Rucinski of the Warsaw University Observatory argued that HD 36705 was not an FK Comae star but instead a young, rapidly spinning star similar to the late-type rapid rotators recently discovered in the Pleiades (see "Rapid Rotation in the Pleiades," ASTRONOMY, December 1984, p. 64). Rucinski based this belief on the intensity of a lithium line located at 6707 angstroms. The nuclear reactions in stars quickly deplete lithium, so the element is only abundant in very young objects. Thus, HD 36705's high lithium abundance indicates it is a young star rather than an evolved one. Furthermore, Dorren, Guinan, and George McCook reported in 1984 that HD 36705 did not show the strong chromospheric emission lines — such as Mg II — which distinguishes the other FK Comae stars. That same year, Bopp and his colleagues discovered that one of the three original FK Comae stars — UZ Librae — is actually a binary, and thus not a true member of the class.

While these scientists were casting HD 36705 and UZ Librae out of the FK Comae family, another team of astronomers admitted a new member in 1983. While monitoring a number of stars, they found that one on their list — Psi^3 Piscium — was a G-type giant with a V sin I of 100 km/sec. This is by far the brightest FK Comae star known; with an apparent magnitude of 5.55, it's barely visible to the naked eye.

Scientists continue hunting for more FK Comae stars — they need all they can find to understand this bizarre phenomenon. Already there's an unconfirmed report of an FK Comae star in the ancient open star cluster NGC-188 in Cepheus. It wouldn't be a surprising place to find one of these objects, for the cluster also contains several contact binaries as well.

Although the progenitors of FK Comae stars — contact binaries — are quite common, the FK Comae stage is probably brief and these stars could be rather rare. The FK Comae stage cannot last long because the star's rapid rotation creates strong magnetic fields. These fields make starspots as they emerge from the star's interior and extend far out into space, dragging through the interstellar medium. Particles accelerated by the field steal angular momentum from the star, braking its spin. Magnetic braking probably slows the star's spin after only about 100,000 years. Once the star's rotation slows, the strong magnetic field disappears, as do the starspots it creates. The star becomes an ordinary, slow-spinning, late-type giant star.

Is there anything to distinguish such an ex-FK Comae giant from G giants with less exciting histories, or is the secret of the binary's consummation forever buried? Perhaps some other late-type giants, now slowly spinning, were once FK Comae stars, too. No one really knows exactly what happens when two stars coalesce. It's possible that the giant star, though single, retains a double stellar core. At the end of its life, the giant star will shed its envelope and create an expanding shell of glowing gas — a planetary nebula — around its collapsed twin cores. This would be the only time onlookers could deduce the strange history of the star. Right now, we can only speculate!

Ken Croswell is a graduate student at Harvard University. His most recent feature article was "Stars Too Small to Burn," which appeared in the April 1984 issue of ASTRONOMY.

ASTRO MART

FOR SALE — Back issues of ASTRONOMY and *Sky & Telescope*, December 1979 to December 1984, $18 for each year. Contact Joe Candiliere, 201 E. Arrow Hwy. #34, Glendora, CA 91740.

FOR SALE — ASTRONOMY back issues, August 1973 through December 1983, $225 complete. Contact William H. Dunn, Route 2, Tustin, MI 49688. Phone (616) 775-7062.

FOR SALE — 12.5" f/4.5 Cave Astrola with equatorial mount, clock drive, finderscope, and two eyepieces (25mm and zoom 21-7mm). $600 or best offer. Contact Phil Weber, 305 Burwell Ave., Henderson, NC 27536. Phone (919) 438-2246.

FOR SALE — 8" Newtonian with Pacific Industries' equatorial mount and Meade optics including 8" f/6 coated objective, diagonal, motor drive, OR 9mm and OR 25mm eyepieces (1¼"), 2x-3x Barlow #127, focuser #67, and counterweights. Complete unit $400. Contact Clyde Herrington, Rio Star Route, Box 62055, Walsenburg, CO 81089. Phone (303) 428-2833.

FOR SALE — Odds and ends from a lifetime of ATM including books, glass tools, abrasives, small mirrors, and flats. For list, send SASE to M. Irland, 105 River Ridge Rd., New Port Richey, FL 33552 (no phone calls, please).

FOR SALE — ASTRONOMY back issues, August 1973 to December 1974. Excellent condition, $125 or best offer. Contact J. Hutton, P.O. Box 70252, Bellevue, WA 98007.

FOR SALE — 8" Newtonian f/7, Coulter optics, four eyepieces, 8x50 Meade right-angle viewfinder, 2.4" refractor guidescope, heavy-duty ball bearing equatorial with clock drive and circles on 4" pipe mount. $400. Contact F. Simon, 1573 Killdeer Dr., Naperville, IL 60565. Phone (312) 420-2312.

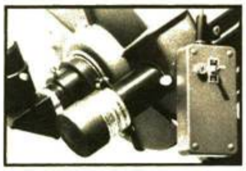
FOR SALE — Questar 3½ telescope with sun filter, 40x-80x and 80x-160x eyepieces, legs, cord, camera adapter, counterweight, leather case, metal storage box. Cost $2473, asking $2200 or best reasonable offer. Phone Allan R. Ansell at (208) 343-7019.

FOR SALE — 48 back issues of ASTRONOMY, November 1980 through December 1984 (March 1982 and December 1983 missing). Excellent condition, $72 plus U.P.S. Contact Wava Enger, 6801 W. 17th St., Sioux Falls, SD 57106.

FOR SALE — Celestron 8 with wedge, tripod, special coatings, 17mm Plossl, 2x-3x Barlow, and books. Excellent condition, great for photography. $850. Contact Fredric Bender, 142 Irwin Ave., Houston, PA 15342. Phone (412) 745-1337.

FOR SALE — 10 used eyepieces (Tele Vue, Meade, Celestron), various focal lengths, mint condition. Also ASTRONOMY back issues. Write for price list to D.R. Hieb, 120 S. Sanborn, Chamberlain, SD 57325.

MOTOFOCUS



pat. pend.

REMOTE CONTROL FOCUSING

End the focusing wiggles —
Fantastic for astrophotography!

Equipped with **ELECTROMAGNETIC BREAKING** and **VARIABLE SPEED.** Celestron installs in 30 sec. Others take longer.

CELESTRON C5, C8, 0-15 rpm $69.95
(Specify age of scope)
CELESTRON C11, C14, 0-6 rmp ... $79.95
DELUXE C14 .... $119.95
(R.A., Dec., focus all in one hand unit.)
MEADE 2080, 2120, 0-12 rpm $79.95
MEADE newt., **NOVAK, PARKS, CAVE, UNIVERSITY** (Requires drill and tap) $59.95

NEW MOTOFOCUS for CELESTRON C-60, C-70, C-80, SP-90, C-100, SP-102 .... $69.95
NEW for **COULTER ODYSSEY** and **MEADE REFRACTORS** Requires drill and tap $59.95

BREAK THROUGH

NEW Dec. motor for video cameras. Fast panning action, yet micro fine control for astrophotography for **C-8, MEADE 2080** . $69.95
Write for info

All orders shipped next day. VISA, MasterCard, or check accepted. Ppd. U.S.A. Foreign via air add $4 U.S. funds.

JIM'S MOBILE IND.
1960 ROAD 23
EVERGREEN, CO 80439
303-277-0304

STAR TRACKER

THE MOST COMPLETE TELESCOPE STORE IN THE KNOWN UNIVERSE

COME IN AND COMPARE

Write for the world's finest telescope Catalog and Reference Manual
$2 U.S.A. $4 Foreign

3093 WALNUT
BOULDER, COLORADO 80302
(303) 442-6805

2080LX3
$1399

Meade®
THE LEADER'S EDGE

PAULI'S OPTICAL
29 KINGSWOOD RD.
DANBURY, CT 06811

203-746-3579
9 a.m. to 10 p.m.
Mon. — Sat.

Complete Catalogs $2.00

Sidereal Clock

$29.95
plus $3.00 shipping

12:09
Sidereal Time
Northeast Instruments

- six month warranty
- continuously updated
- runs on 110-120 volt AC, 60 cycle current
- cumulative error is 1.89 seconds per year

30 day return privilege if not satisfied.

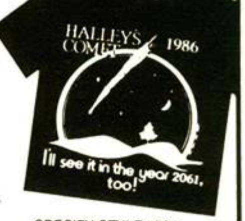
Send personal check or money order to:

Northeast Instruments
P.O. Box 14764
Minneapolis, MN 55414

DESIGNED ESPECIALLY FOR YOUNGSTERS

A Great Gift for Your Child or Grandchild

Beautiful Quality Silkscreen on Royal Blue or Maroon Shirt
Only $8.95 (PPD)


HALLEYS COMET 1986
I'll see it in the year 2061, too!

5 Designs as well as caps,
Travel Bags & Stickers
SEND FOR FREE CATALOG

SPECIFY STYLE #505,
COLOR & SIZE
Junior: 2-4/6-8/10-12/14-16

ASTROLINE PRODUCTS
1925 Juan Tabo NE, Suite B248 • Albuquerque, NM 87112
(505) 821-1268

CANADA

Meade Authorized Dealer

"Compare our selection and price"

master charge

BOOKS, FILMS and TELESCOPES

VISA

QUASAR OPTICS

7719 FLEETWOOD DR. S.E.
CALGARY, ALBERTA T2H OX2
(403) - 255 - 7633

UNBEATABLE

PRICES ON CELESTRON AND OMNICON ASTRONOMICAL TELESCOPES

SOME EXAMPLES:

CELESTRON C-8M Complete with Equatorial Mount, Slow Motion Controls, Tripod, Worm Gear Motor Drive and Slow Motion Polar Axis.	'995
CELESTRON C-11 Complete witih Tripod, Wedge and Slow Motion Polar Axis Controls.	'2495
1. CELESTRON COMET CATCHER	'445
2. OMNICON 515ST 6" f/5 NEWTONIAN	'395
3. OMNICON 158ST 80MM f/15 REFRACTOR	'325

All three complete with Equatorial Mount, Slow Motion Controls, Worm Gear Motor Drive, All Metal Extendable Tripod and more!

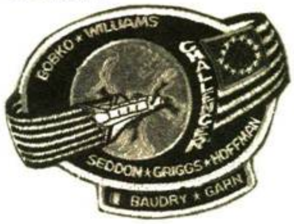
$2.00 — 24 PAGE
ASTRONOMICAL CATALOG

Sky Instruments • Box F195-105 • Blaine, WA 98230
Canadians: MPO Box 3164 • Vancouver, B.C. • V6B 3Y6

(604) 270-2813

Join *Challenger's* 51E Crew with NASA's Official Patch

This multi-colored embroidered patch commemorates February's launch of NASA's second TDRS tracking satellite and a Canadian communications satellite. Great for your jacket or cap!



STS-51E   5¼" x 4" $4.95

To order, use the AstroMedia order form bound into this magazine, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

ASTRO MART

FOR SALE — Celestron 11 with many extras including weights, 2" Erfle, 2" Barlow, giant diagonal, 2" 70mm Kellner, and more. $2000 takes all. Contact Stanley Worsh, 93 W. 25th St., Bayonne, NJ 07002. Phone (201) 437-7203.

FOR SALE — *Amateur Telescope Making* (3 volumes), $60 Can. ($50 U.S.); cloth-bound *Atlas Borealis* and *Atlas Eclipticalis*, $60 Can. ($50 U.S.). Will swap for HP-41 Extended Memory module. Contact Ross Cooling, 170 Redpath Ave., Toronto, Ontario, Canada M4P 2K6. Phone (416) 488-3314.

FOR SALE — 17.5" Dobsonian telescope with 2" rack and pinion and 8x50mm University finder. In excellent condition, $650 or will sell components separately for best offer. Contact Steve Kalasky, 2948 Newton Falls Rd., Newton Falls, OH 44444.

FOR SALE — Unitron 2.4" equatorial refractor, two years old, mint condition, $250. Unitron 10x42mm finderscope, $25. Lumicon 80mm superfinder for right-angle viewing, $50. All prices include shipping. Contact Rick Clark, 117 Tanglewood, Keene, NH 03431. Phone (603) 357-1652.

FOR SALE — Hewlett-Packard HP-110A portable computer, IBM compatible; includes Lotus-123, word processing, term emulator, and modem. Brand new. Purchase price $2995, will sell for $2450. Also selling HP-9121D dual-disk drive for $975. Contact Fred Bay, 3291 Cutter Ln., Maineville, OH 45039.

METEORITES

AVAILABLE TO
ASTRONOMERS, SCHOOLS
INSTITUTIONS AND PRIVATE
COLLECTORS. STONES & IRON
SPECIMENS. **LIMITED SUPPLY.**
ROBERT A. HAAG — METEORITES
Box 27527, Tucson, AZ 85726

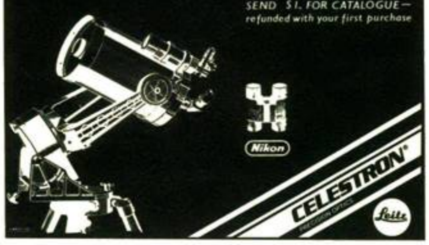
— PLEASE SEND $1.00 FOR FULL COLOR CATALOG —
Refundable on first order

TOWSON PHOTO SUPPLY
401 WASHINGTON AVENUE
TOWSON, MD. 21204
301·296·1717

CELESTRON TELESCOPES - BINOCULARS - CAMERAS

A FULL LINE DEALER SERVING THE EAST COMPETITIVELY

SEND $1. FOR CATALOGUE — refunded with your first purchase



Tele Vue Optics

from Optics Ohio

Plossis 50° field (except 40mm)

Focal Length	O.D.	Price
55 mm	2.00"	$175
40, 32 mm	1.25"	95 each
26, 21, 17, 13 10.4, 7.4, 2.5x	1.25"	80 each

Naglers 82° Field of View			Wide Field 65° Field of View		
13 mm	2/1.25"	$235	40 mm	2.00"	$265
19 mm	2/1.25"	210	32 mm	2.00"	210
4.8 mm	2/1.25"	140	24 mm	1.25"	140
			19 mm	1.25"	125

SPECIAL OFFER: Any TeleVue order of $250 or more will receive FREE Sky Atlas 2000 Deluxe ($35 value). Offer good thorough July 15, 1985.

*Dealer for major brands *Complete catalog $2.00

OPTICS OHIO
"A Division of Cosmic Connections, Inc."
P.O. Box 1439, Lancaster, Ohio 43130
Telephone inquiries accepted at our corporate office
312-851-5353

OBSERVE HALLEY'S COMET FROM:

PERU	AUSTRALIA
$1,180*	**$1,850**
8 Days, Air (NY)**	14 Days, Air (NY)**
1st Class Hotels	Hotels, Fly/Drive
Transfers	Itinerary Includes Car Rental
Guided Tours	
4 Tour Locations	

WHY PAY MORE?

Very Limited Space, Contact NOW!!

A-OK Enterprises
75 Timberline Dr.
Brentwood, NY 11717
(516) 231-3191

*Based on 1986 Estimated Costs
**Departure from other locations

Tours Conducted Through Ronbee Travel

NEW ENGLAND ASTRO-OPTICS, INC.

• QUESTAR • MEADE • TELEVUE •
BUSHNELL/BAUSCH & LOMB • JSO
COULTER LUMICON

master charge

VISA

CATALOG PACKAGE $2.00
Box 834, Simsbury, CT 06070
203-658-0701

TCU 685 OUR 2nd YEAR 70055,205

TEXAS NAUTICAL REPAIR CO.

Authorized Meade Dealer

COME AND SEE
THE FINE TELESCOPES AND ACCESSORIES BY MEADE IN OUR SHOWROOM. WE HAVE IT ALL AND OTHER POPULAR MAKES.

2129 Westheimer
Houston, Texas 77098
(713) 529-3551

Master Card American Express Visa

---

*CHICAGOLAND'S astronomical headquarters

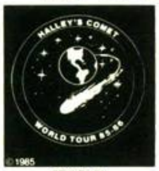
*Demonstrations on clear evenings

*Dealer for Celestron, TeleVue, Meade, University, Lumicon, Coulter's, Odyssey, Bushnell, Bausch & Lomb, books, charts, T-shirts, & globes.

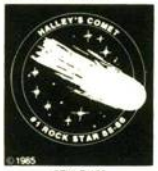
Cosmic Connections, Inc.
1460 N. Farnsworth Avenue
Aurora, Illinois 60505
312-851-5353

VISA-MasterCard-American Express

THE COMET IS COMING!

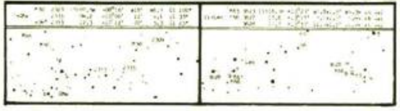


STYLE 101



STYLE 102

T-SHIRTS $12.50 + $1.50 Postage & Handling.
S-M-L-XL. White on Black.
All Shirts are Silk-Screened on *Quality Cotton*.
Specify Size & Style No.
Send Check or Money Order to:
J&S ENTERPRISES
370 E. 76 St. Suite C-703
NYC NY 10021
Allow 4-6 weeks Delivery. Dealer Inquiries Welcome



INDEX CARD FINDER CHARTS

Made especially for use at the telescope!
75-handy 3x5 star-charts per set.

SET I - THE MESSIER OBJECTS	$7.50
SET II - THE FINEST NGC OBJESTS	$7.50
SET III - THE FINEST DOUBLE STARS	$7.50
SET IV - THE FINEST NGC, Part B	$7.50

2 or more sets, $7.00 ea. 4 or more $6.50 ea.

NEW! OBSERVER'S LOGBOOK

For recording & drawing observations of planets, Sun, comets, deep-sky. 3-ring binder & 100 observing forms. Send for info. $16.95.

Send 37¢ stamp for FREE slide catalog. Outside USA add 20% extra for airmail postage.

ASTRO CARDS
P.O. Box 35, Natrona Heights, PA 15065

CELESTRON TELEVUE MEADE

CELESTRON NIKON MEADE TELEVUE BAUSCH & LOMB SWAROVSKI

The Buyer's Guide To The Galaxy...

Meade	**Celestron**
• 2044/2080 LX3	• Super C-8 Plus
• DS-10	• C-90 Astro
• 1250 Comet Seeker	• Cometrons

Giant Binoculars
Tele-Vue Eyepieces
- Naglers
- Wide Fields
- Plossls

Precision Optics At
Berger Bros.
Camera Exchange
Call or Write Joe or John:
209 Broadway (Rte 110)
Amityville, NY 11701
(516) 264-4160
We ship UPS in 48 hours.

CELESTRON NIKON MEADE TELEVUE BAUSCH & LOMB SWAROVSKI

CELESTRON TELEVUE MEADE

CELESTRON® TELESCOPES AT LUMICON

PRECISION OPTICS

Call 800-223-7629 (CA Orders Only)
or (415) 447-9570 (Orders & Information)

SUPER POLARIS C-8, $849

The new Celestron SP-C8 8"f/10 telescope includes 6x30mm finderscope, 80x eyepiece, super polaris equatorial mount, tripod and accessory tray. **It is ready for viewing!** It also has slow motion controls, polar alignment finder and setting circles. Motor drives or computer control are optional.

SP-C8 Super Polaris C-8, incl. mount	$849
SP-C8 with special coatings	$995
SP-C8 w/ starbright & special coatings	$1180
R.A. motor & single axis drive corrector	$139
Dual-axis drive corr., RA & dec motors	$198
"Sky Sensor" Computer Control	$450
Dew shield keeps front lens dry	$48

COMPUTER CONTROL
$450

The new Celestron "Sky Sensor" provides computer control for all telescopes with Super Polaris mounts listed here. Automatically searches out all Messier objects & many NGC objects & bright stars listed in computer memory. Also includes electric declination & right ascension pulse motors.

SUPER C-8 "PLUS" SYSTEM

Standard, $1475
Deluxe, $1545

Super C-8 "Plus"

Celestron 8"f/10 black Super C-8 w/ all standard & "Plus" accessories. The standard system includes wedge & Meade heavy-duty adjustable field tripod. The Deluxe System also includes a dew shield and accessory tray ($85 value) Starbright enhanced silver coatings, **add $150.**

New Celestron 102mm f/9 FLUORITE Apochromat refractor on Super Polaris Mount

NEW CELESTRON TELESCOPES

All telescopes below have equatorial mounts, slow motion controls, setting circles, tripod, 26mm Plossl eyepiece. See SP-C8 prices for optional drives or computer control.

REFRACTORS

C60E, 60mm f/15 refractor ($50 list)	$350
C8-80, 80mm f/11.4, alt-azimuth mount	$470
C80, 80mm f/11.4 refractor ($1000 list)	$580
SP-C80, 80mm f/11.4 refractor ($1100 list)	$670
SP-C80F, 80mm f/8 Fluorite ($2000 list)	$1190
SP-C102, 102mm f/10 refractor ($1600 list)	$895
SP-C102F, 102mm f/9 Fluorite ($3000 list)	$1795
2" accessory adapter for Fluorite refr.	$39
2" LUMICON EASY-GUIDER (state camera)	$149

REFLECTORS

CO-114, 4½"f/8 Newtonian ($600 list)	$449
C130, 5"f/5.5 Newtonian ($800 list)	$595
SP-C6, 6"f/5 Newtonian ($1200 list)	$750
SP-C8, 8"f/10 Schmidt-Casse. ($1375 list)	$849
RA motor & drive corr. (specify tele.)	$139

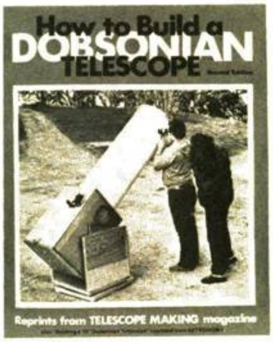
Shipping added to telescopes. Prices subject to change w/o notice. LUMICON carries the complete line of Celestron telescopes and accessories. Catalogue $3

LUMICON 2111 Research Drive, #5A
Livermore, CA 94550 (415) 447-9570

REVISED, EXPANDED SECOND EDITION

HOW TO BUILD A DOBSONIAN TELESCOPE

Reprints from Telescope Making and **ASTRONOMY** Magazines



How to Build a DOBSONIAN TELESCOPE

Reprints from TELESCOPE MAKING magazine

Would you like to build your own 10″ telescope? Well, you can — and for a lot less time and money than you thought. Our 52-page booklet gives you complete instructions on how to build a 10″ Dobsonian — plus helpful diagrams and plenty of informative articles and photographs on 12″, 16″ and 20″ scopes. This new and expanded edition also tells you how to calculate bearing size, how to use a Poncet platform for deep-sky astrophotography, and how to use setting circles and your pocket computer to find your favorite celestial objects.

This is a complete Dobsonian manual — covering each step from choosing materials to aiming your new 'scope.

ONLY
$4.95

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

Tele Vue™

Send for free guide: "Choosing Your Eyepieces"

Tele Vue 50°
PLÖSSL EYEPIECES

"SHARPEST I'VE EVER USED"

TELE VUE 32MM PLOSSL

"Used with my 12″ f/7, the Plössls deliver crisp images of the planets. I have the distinct impression that the eyepiece adds no optical errors to the image I'm viewing, and that I am seeing everything the mirror can deliver. This is an impression I've never had with any other eyepiece. Tele Vue Plössls are the sharpest I've ever used." — From review in August '81 "Astronomy"

New 4 element design improves performance of any telescope. Exceptional contrast and resolution over the entire 50° field, even with fast Dobsonians. Ideal for astrophotography too. Multi-coated. Chromed barrels threaded for filters.

55mm (2″ barrel),
40mm & 32mm (1¼″ barrel)
have widest fields possible for low power viewing. 7.4mm to 32mm models parfocal. 2.5x Barlow is a matched parfocal design. Actually improves eyepiece performance.

PLÖSSLS	
55mm	$175
40mm	95
32mm	95
26mm	80
21mm	80
17mm	80
13mm	80
10.4mm	80
7.4mm	80

BARLOW	
2.5x	80

Tele Vue 65°
WIDE FIELD EYEPIECES

A MAJOR NEW ADVANCE!

VUE 24MM WIDE FIELD

New 6-element design (pat. pend.) with a very wide 65° field. Significantly sharper than Erfles and König wide angle eyepieces. Field for field it rivals our Plössls. Almost essential for fast telescopes. Multi-coated.

40mm and 32mm Wide Field models have 2″ barrels. 24mm and 19mm have 1¼″ barrels and are parfocal with our Plössls. "First wide angle eyepiece with snap imaging." —John Vogt, New York

WIDE FIELDS	
40mm	$265
32mm	210
24mm	140
19mm	125

Tele Vue 82°
NAGLER EYEPIECES

EXPERIENCE A SPACEWALK!

TELE VUE NAGLER

Patented 7-element design introduces a new dimension in observing. Dramatically more field, sharpness and eye relief than any commercial eyepiece. Multi-coated. Dynamite with Dobsonians.

Naglers fit 1¼″ barrels. 9mm and 13mm also fit 2″ barrels. 9mm and 4.8mm parfocal too.

"With the NAGLER 9, the field is so wide and sharp in my C-8, the telescope seems to 'Get out of the way.' Amazing—a picture window with magnification." — Pat Walker, Virginia

NAGLERS	
13mm	$235
9mm	210
4.8mm	140

TeleVue PH. 914-735-4044
20-A DEXTER PLAZA, PEARL RIVER, NY 10965

All Tele Vue eyepieces sold with money back guarantee. Shipped postpaid in continental U.S. Residents of N.Y., please add sales tax.

Observing the Apollo 17 Lunar Landing Site

by Herbert Holder

About twenty years ago, lunar astronomy began to wither and die — at least in the minds of many backyard observers. Luniks, Rangers, and Lunar Orbiters were sending back first tens, then hundreds, and finally thousands of Moon pictures.

It was magnificent, thrilling — and profoundly discouraging. Suddenly, all those countless hours spent at the eyepiece seemed pointless. Robots were taking photographs from lunar orbit that blew their Earth-bound competitors right out of the water. By the time the Apollo missions actually lifted off for the Moon, the professionals had taken up permanent residence in what had been the private preserve of every amateur astronomer.

For some backyard observers, this chopped the heart out of lunar astronomy. It broke something in them that even worthwhile projects like watching for transient volcanism and mapping the few unmapped regions couldn't wholly mend — a sense of it being "our" Moon, perhaps.

But is this really a tragedy? After all, for the typical backyard astronomer, exploring the Moon has always been a vicarious experience and that hasn't changed a bit. When you train your scope on the Moon, you observe what's there all the more because of the close-up photos you've seen. They've prepared you: Aren't Hadley Rille and the Apennine Mountains now more real in your eyepiece, thanks to Apollo 15?

It doesn't matter that no telescope on Earth will show you the lunar modules, the rovers, and the surplus equipment left behind. What counts is being there in spirit. Even small to moderate-sized instruments can show you lunar features about as large as the distances traversed by the Apollo astronauts — and finding the actual sites themselves is a tremendous thrill.

The landing site of Apollo 17 is especially appealing. Besides being the last area visited, it has such unusual topographic features that it's surprising few backyard observers seek it out. Apollo 17 landed in a valley just south of the crater Littrow in the Taurus mountains, along the eastern "shore" of Mare Serenitatis. This valley has several unique features which make it easy to identify at the telescope.

Normally, the best times to observe lunar features are right after local sunrise and soon before local sunset. Under a low Sun, mountains and craters stand out boldly, casting long shadows behind them. But the Taurus-Littrow site is different: the valley floor, as well as several adjacent to it, is dark compared to the rest of the lunar surface. In fact, the floor appears black at Full Moon and is one of the darkest regions on the visible lunar hemisphere. Therefore, ignore the usual advice and look for the site at Full Moon, when the contrast between the dark valley floor and the bright surrounding mountains is strongest.

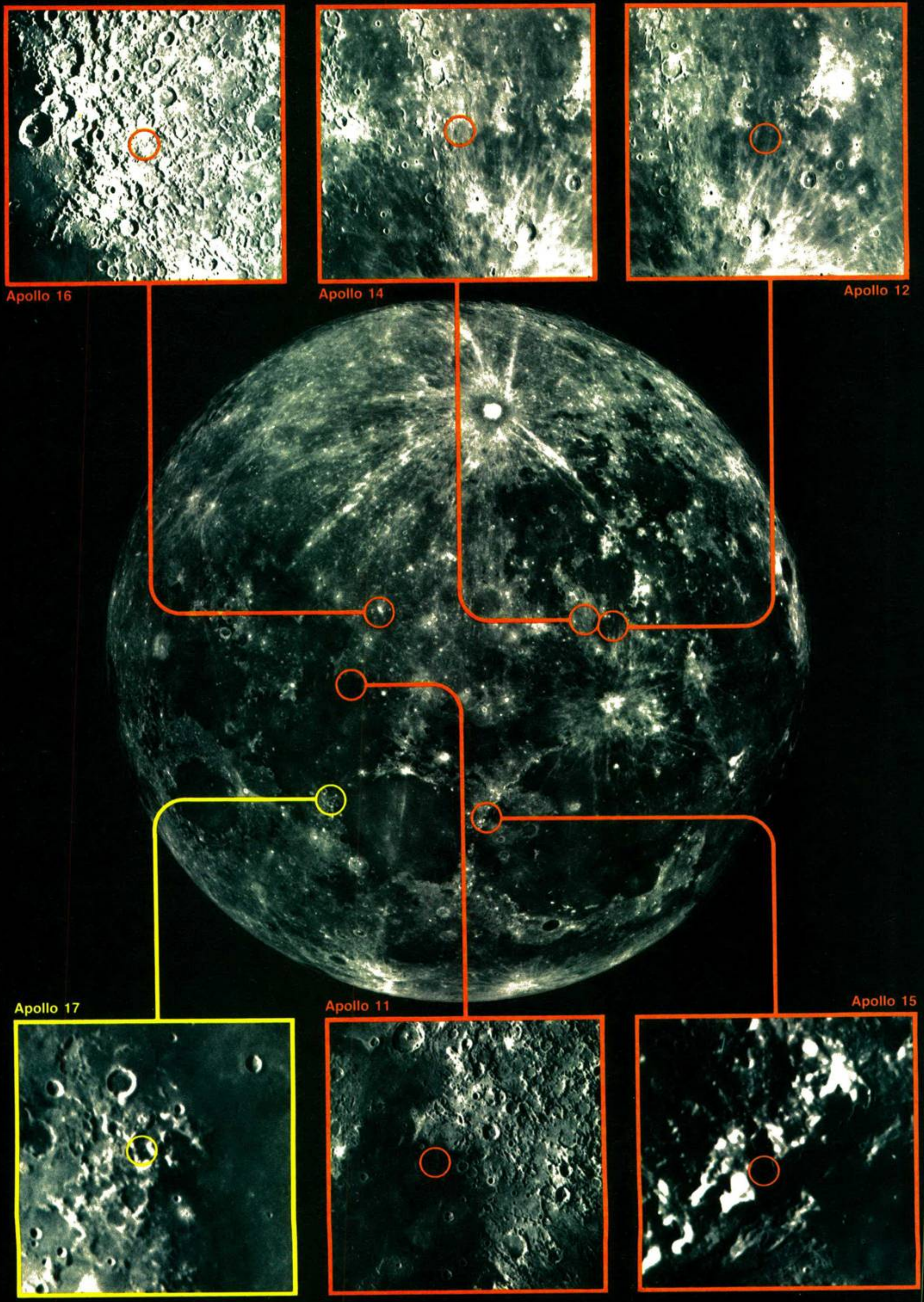
Missions to the Moon

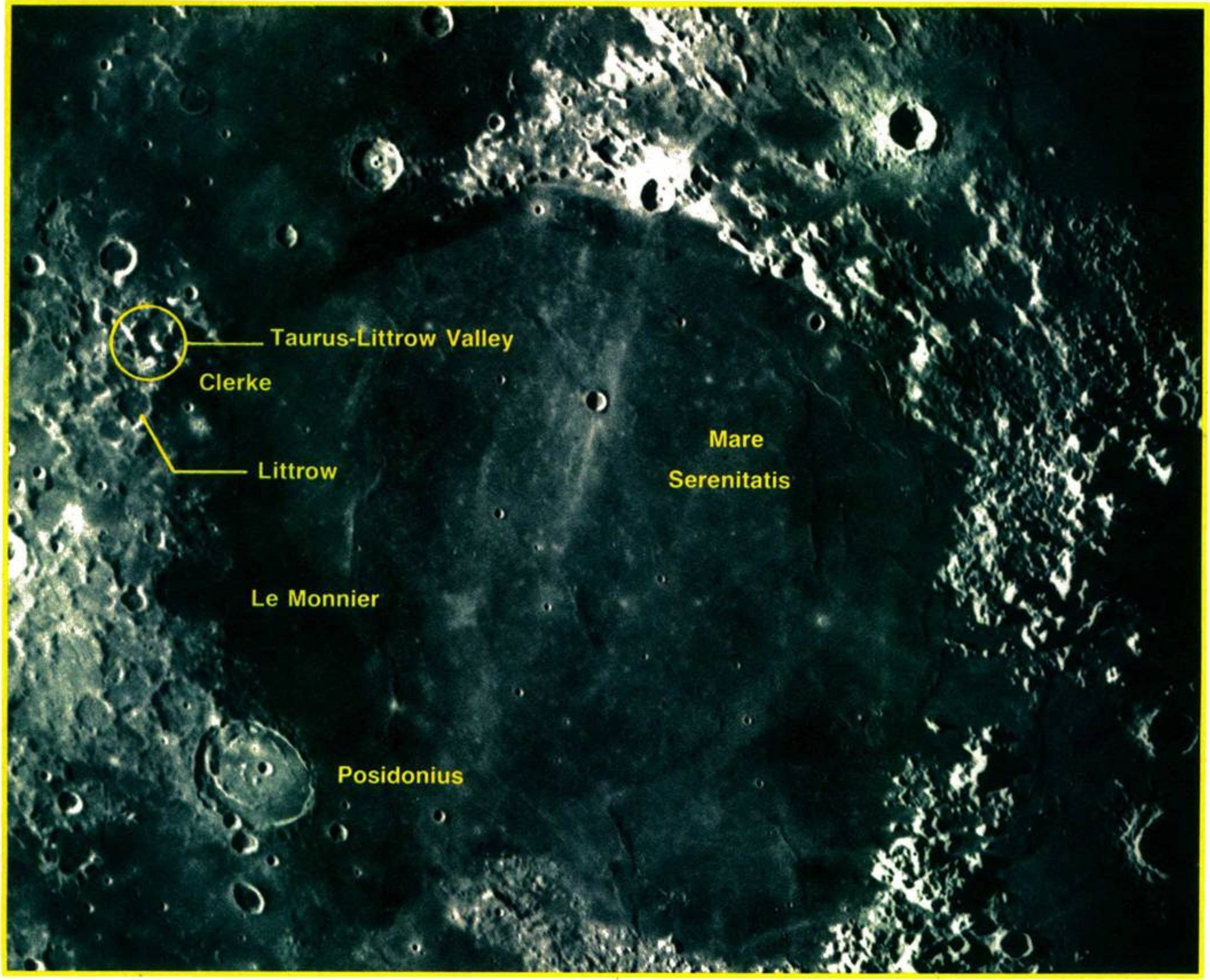
Mission	Landing Site Latitude	Landing Site Longitude	Distance Covered	Samples Returned	Launch Date
Apollo 11	0° 40′ N	23° 29′ E	0.3 km	21 kg	July '69
Apollo 12	3° 12′ S	23° 24′ W	2.0	34	Nov '69
Apollo 14	3° 40′ S	17° 28′ W	3.3	43	Jan '71
Apollo 15	26° 06′ N	3° 39′ E	27.9	77	July '71
Apollo 16	9° 00′ S	15° 31′ E	27.0	94	Apr '72
Apollo 17	20° 10′ N	30° 31′ E	35.0	110	Dec '72

A note about observing: the features you're looking for are small indeed — you'll need high magnification to observe them well. This in turn calls for excellent optics, tranquil seeing, and a sturdy mounting — preferably an equatorial with a clock drive or smoothly operating manual slow motions. You can pick out the Taurus-Littrow area with about 100x magnification, but you'll need 200x to 300x to explore the terrain. When you have found the site at Full Moon, be sure to view it under a low Sun, too. The Moon is Full on May 4th and the evening terminator will pass the valley about four days later. After New Moon, sunrise at Taurus-Littrow comes around May 25th.

The valley, very approximately circular, is about 12 miles across with an angular size of some 10 arc-seconds. (Compare this to the 30, 15, and 4 arc-second minimum diameters of Jupiter, the ball of Saturn, and Mars.) The challenge of observing or photographing the Taurus-Littrow valley is therefore no harder — and in some ways easier — than seeing and capturing fine detail on the planets. Jovian features are notoriously low in contrast — the same goes for Saturn and Mars — but they can be seen and photographed. At Taurus-Littrow, the job's easier since you have the Moon's high contrast helping you.

To find the site, start at the prominent crater Posidonius on the eastern shore of the Sea of Serenity. Scanning slowly southward, you will pass the large flooded and breached crater Le Monnier, which lies halfway between Posidonius and a small (4.5-mile diameter) crater on the mare named Clerke (Littrow B on old maps). Clerke has a fresh impact crater nearby with a very bright ejecta apron around it. Littrow itself is a crumbly, somewhat indistinct crater in the hills due east of Clerke. The valley where Gene Cernan and Jack Schmidt set down their lunar module Challenger is about one Littrow-diameter south-southwest of Littrow. Look for a roundish dark patch almost wholly surrounded by light-colored


Apollo 16
Apollo 14
Apollo 12
Apollo 17
Apollo 11
Apollo 15



Left: All the Apollo missions stayed relatively close to the lunar equator to simplify engineering problems. Above: A finder chart for the Apollo 17 landing site at the Taurus-Littrow Valley. Note that south is at top. All photos courtesy of Lick Observatory except for the Apollo 12 and 14 close-ups which are from Mt. Wilson and Las Campanas Observatories.

hills. Taking your time, carefully compare the eyepiece view with the photo. The valley looks about twice the size of Clerke and half that of Littrow. It may take a few tries the first time to find the area, but refinding it later will be a cinch.

Closed at its eastern end, the valley is almost pinched shut on the west by two large mountains on the north and south. Each is about one to one-and-a-half miles high. Roughly four miles of valley floor separate these enormous features, but the gap between them is easy to trace by the dark material threading through it. The two mountain massifs appear bright and beaconlike.

Part of the southern massif is actually a gigantic landslide, which has carried material downslope and out onto the flat valley floor. The landslide extends approximately halfway across the gap between the two massifs, and its eastern edge comes to within about two miles of where the lander craft touched down. You can catch a hint of its extent by comparing the Full Moon view (where the landslide looks like part of the mountain) with that at sunrise or sunset. In effect, the apparent narrowness of the valley's throat changes as the lunar phases sweep through their cycle. Running roughly north-south across this throat is a scarp with an east-facing edge. (It was called "Lincoln scarp" by the astronauts.) At high power with excellent seeing conditions, a large scope, and the right lighting (immediately after sunrise, for example), this scarp ought to be visible as a light, hair-thin line.

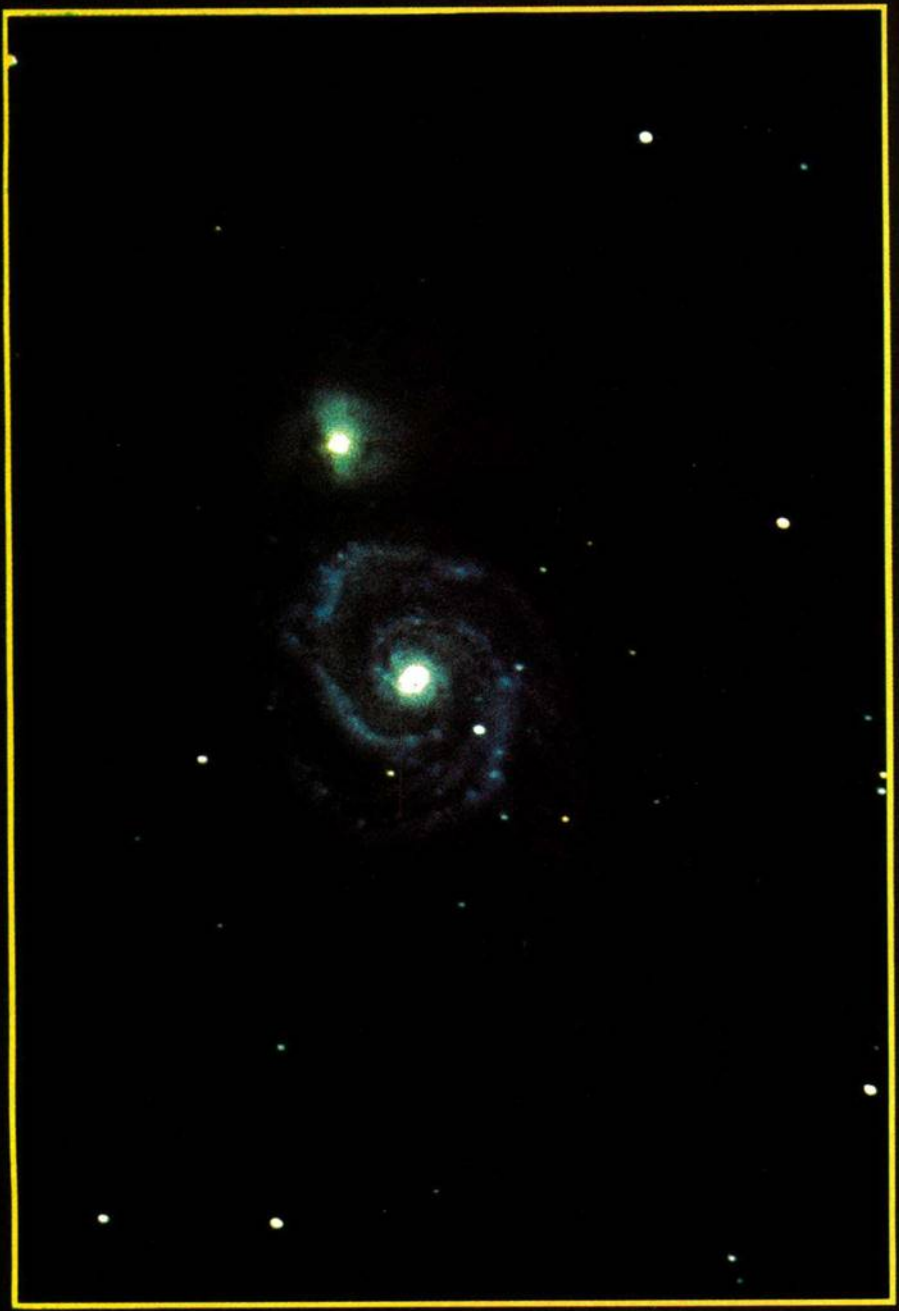
On the floor of the valley are many crater pits ranging in size from half a mile in diameter downward, but these lie beyond the resolution of nearly all backyard instruments. There is a hillock just to the east of the south massif that stands out as a tiny bright spot at Full Moon; the astronauts dubbed it "Bear Mountain." Just outside the valley (west of the throat) is a larger bright hill called "Family Mountain" during the mission.

The Taurus-Littrow site was chosen for exploration because geologists thought the dark lava filling the valley would be very young. (Lunar mare material tends to lighten with exposure.) If the lava was young, so theory said, then the Moon's internal fires might not yet be wholly banked. But rock samples taken in the valley turned out to be disappointingly old: 3.7 billion years — the same as many lunar rocks sampled elsewhere. Even some fresh-looking orange soil had the same age.

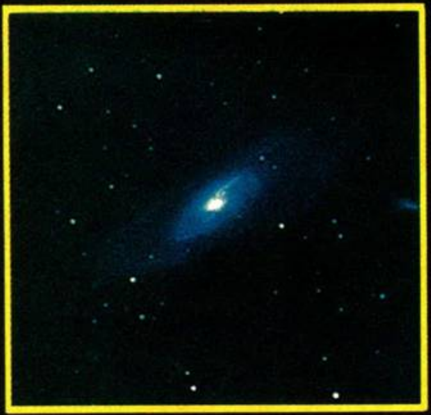
Although it was a disappointment in some respects, the last of the Apollo Moon flights visited some of the best scenery of the whole program. Who can forget the sight of Jack Schmitt dwarfed by a huge broken boulder — or the astronauts' lunar rover making lonely tracks across a hill-hemmed lunar plain?

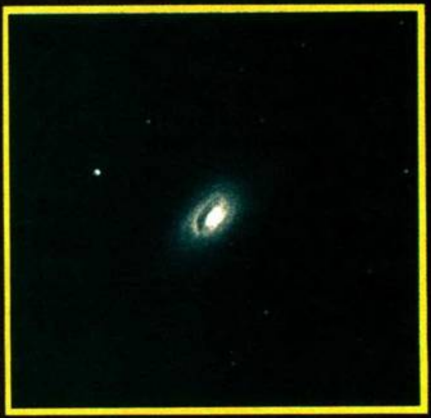
Unlimber your telescope next Full Moon, turn it toward the Sea of Serenity, and take a vicarious EVA with the crew of Apollo 17 to explore the place where mankind last touched the Moon.

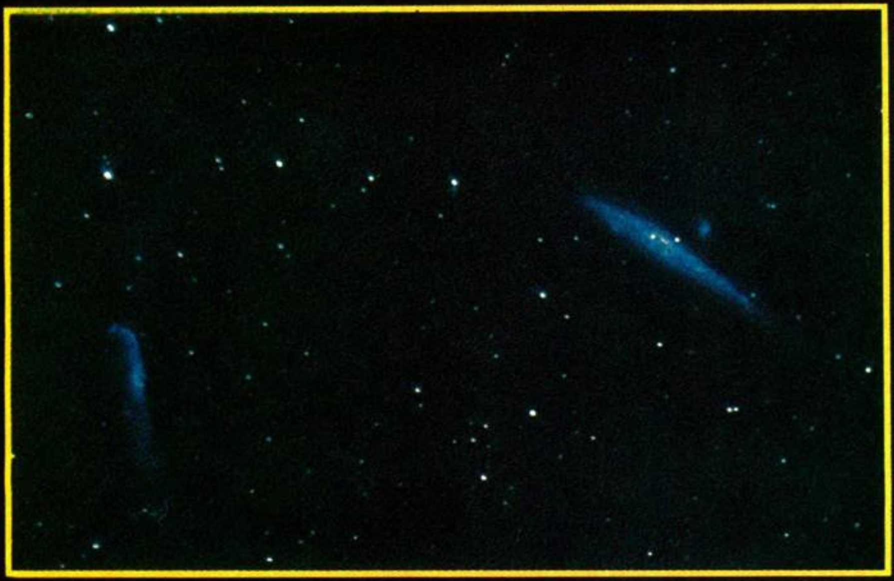
Herbert Holder's amateur interest in the Moon led him to a career as a physicist. Selenography is still a primary interest.

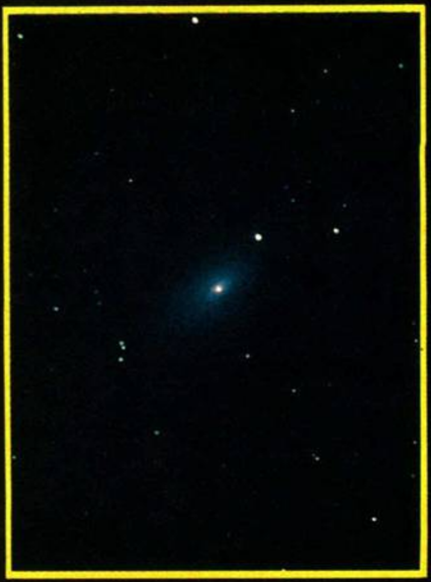


Left: M-51, the Whirlpool Galaxy, is one of the finest spirals in the sky. When observed with a 4-inch or larger telescope, M-51 appears as two distinctly separate patches of light in contact. Photo by Ben Mayer. Below left: NGC-4656 (left) and NGC-4631 are two distorted galaxies lying within the same low-power field. Photo by Jack Marling. Below: M-106 is one of the brightest spiral galaxies in the northern sky. Photo by Jack Marling. Below center: M-64, the Blackeye Galaxy, is well known for its easily observed dust patch. Photo by Preston Justis. Bottom: M-63 shows a tiny nucleus surrounded by knotty tightly-wound spiral arms. Photo by Jack Newton.



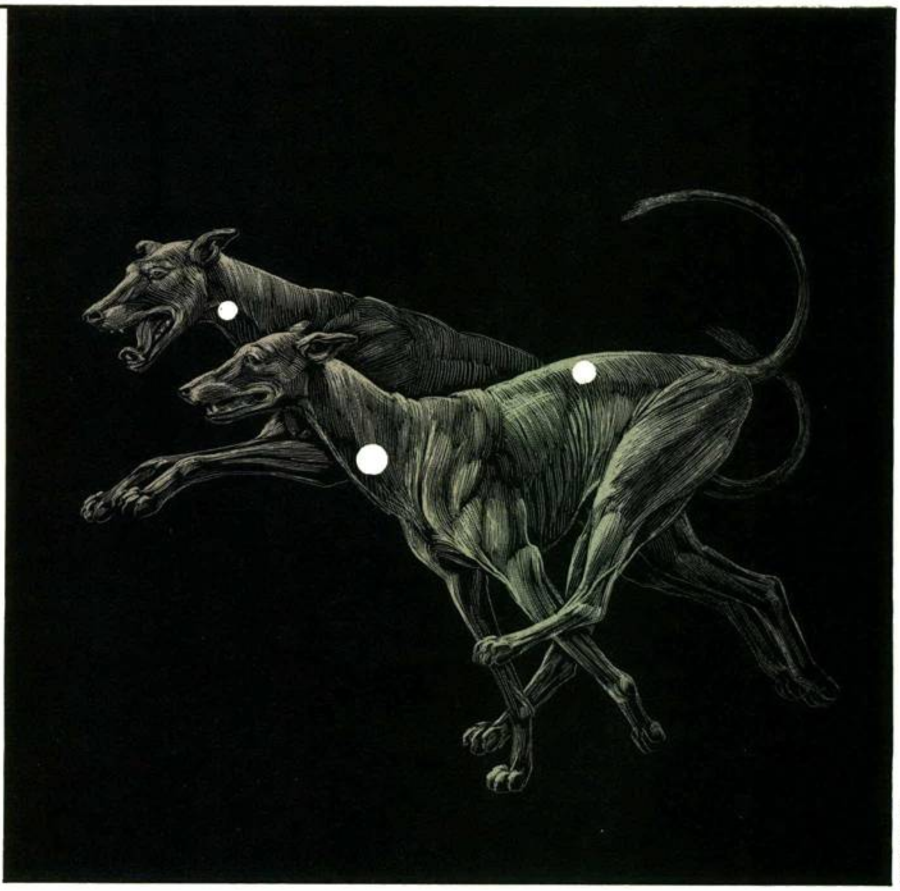






Canes Venatici

CVn
Canum Venaticorum



Keith Ward

Canes Venatici, the Hunting Dogs, consists of three faint naked-eye stars. It is inconspicuously tucked between the familiar constellation Ursa Major and the great cloud of galaxies spread across Virgo and Coma Berenices. In fact, Canes Venatici is richest in galaxies, most of which belong to the Virgo supercluster.

Canes Venatici's finest object — indeed one of the best galaxies in the sky — is **Messier 51** (NGC-5194). Just to the north of it is **NGC-5195**, a small irregular galaxy currently interacting with the larger spiral. Some 3½° southwest of Eta (η) Ursae Majoris, the end star in the Big Dipper's handle, M-51 is a large face-on spiral known as the Whirlpool Galaxy due to its graceful form. M-51 shines at magnitude 8.7 and covers some 10.0′ x 5.5′ of sky, making it easy to spot as a fuzzy patch with large binoculars or small telescopes. A 2-inch refractor reveals a 5′ diameter roundish patch of weak light. Large telescopes show considerable detail: a 12-inch scope reveals the subtle spiral structure across the galaxy's face, a dim star seen projected on M-51's surface, dark mottling across both galaxies, and a tenuous bridge of material arcing from the spiral over to NGC-5195.

The M-51 system lies only about 10 megaparsecs away, which accounts for its great size and brightness. For small telescopes, it is one of the finest examples of two galaxies interacting, but not the only such object in Canes Venatici.

The galaxies **NGC-4485** and **NGC-4490** also comprise an interacting system. Although visible in backyard instruments, they are much fainter than the M-51/NGC-5195 pair, so you'll need at least a 6-inch scope to find them. NGC-4490 is a 10th magnitude spiral measuring 5.0′ x 2.0′ — almost exactly half the size of M-51. NGC-4485, some 3′ to the north, glows at only magnitude 12.5 and spans a mere 1.3′ x 0.7′ of sky. This strange galaxy is variously classed as either a peculiar elliptical or an irregular system. On a dark night, a 6-inch scope will show NGC-4490 as a typically oval galaxy with a bright center; NGC-4485 appears as a tiny, fuzzy "star" with a bright center.

For information on naked-eye sky viewing, including planets, constellations, and mythology, see **Eye on the Sky**.

Almost due east of the NGC-4485/NGC-4490 pair are two bright Messier galaxies offering lots of detail for backyard telescopes. **M-94** (NGC-4736) is a bright, compact, tightly-wound spiral — unmistakable as a galaxy in any telescope. It measures 5.0′ x 3.5′ across and shines at magnitude 8.9. Upon looking at M-94 with a telescope larger than 5-inches' aperture, you should notice one obvious characteristic: the galaxy's nucleus is a brilliant, condensed pinpoint which seemingly shines right through the surrounding nebulosity. Telescopes in the 16-inch and larger range show a bright ring of nebulosity centered on the intense core, and dusty mottling inside the outer halo of light.

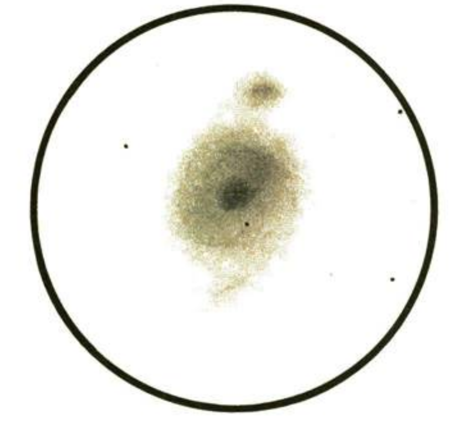
Continuing eastward from M-94, we come to the fine spiral **M-63** (NGC-5055). This is a multiple-arm spiral covering some 9.0′ x 4.0′ of sky and glowing with the light of a magnitude 9.8 star. Recognizable as a galaxy in telescopes as small as 2-inches' aperture, M-63 shows no detail unless viewed with medium or larger backyard telescopes. A 6-inch scope at high power reveals a bright core surrounded by a smooth envelope of nebulosity. A 10-inch scope exposes an oval shaped core, which lies in the midst of a mottled haze — the light from M-63's spiral arms. M-63 lies roughly 10 megaparsecs away — the same distance as M-51.

Another large, bright Messier galaxy lies in the northwest corner of Canes Venatici. **M-106** (NGC-4258) is a ninth-magnitude object measuring a whopping 19.5′ x 6.5′; despite being spread over such a large area, its surface brightness is remarkably high. Even when viewed with a 2-inch scope, M-106 is unmistakably nebular and *looks* like a galaxy. A 6-inch scope under dark skies reveals the nuclear region as a bright oval, with mottling around its periphery and a very faint outer halo of nebulosity. A 17.5-inch telescope easily shows the galaxy's inclined spiral structure and dusty patches in and around the nucleus.

Positioned halfway between M-106 and the interacting pair NGC-4485/NGC-4490 is an odd, box-like object designated **NGC-4449**. Aim a 6-inch or larger telescope at this object and you'll be startled: you'll see a more-or-less hard-edged rectangle of light! This 10th magnitude patch, 4.2′ x 3.0′ in diameter, is an unusually-shaped irregular galaxy. At high power with a 17.5-inch telescope,

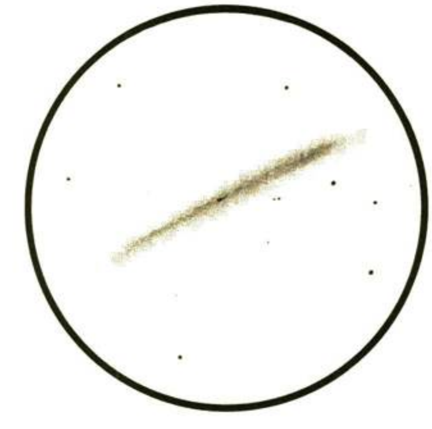
M-51

17.5-inch f/4.5
reflector
100x



NGC-4244

17.5-inch f/4.5
reflector
100x



Sketches by David J. Eicher

NGC-4449 appears as a mottled rectangle with a bright center and knots of material at one edge. These knots may be bursts of recent star formation. In any case, NGC-4449 makes for a peculiar change of pace from the Messier galaxies in Canes Venatici.

Three galaxies lie in the extreme western portion of the constellation. **NGC-4151** is an 11th magnitude barred spiral galaxy with a bright nucleus. It measures 2.6′ x 1.5′ in extent and can be glimpsed with a 3-inch instrument under dark skies. Much more impressive is **NGC-4244**, an edge-on spiral brighter than 11th magnitude and measuring 13.0′ x 1.0′ across. Of the sky's bright edge-on spirals, NGC-4244 almost compares to nearby NGC-4565 in Coma Berenices, the sky's best edge-on "needle" galaxy. A 4-inch telescope shows a slender streak of greyish-green light spanning ¼ the length of the Moon. No detail is visible with larger backyard instruments, but the apparent brightness of the galaxy grows rapidly with more aperture. **NGC-4214**, south and slightly west of NGC-4244, is a magnitude 10.5 irregular galaxy. It covers 7.0′ x 4.5′ and appears as a homogeneous patch of nebulosity in a 6-inch telescope.

The southwestern edge of Canes Venatici holds three other notable galaxies. **NGC-4395** is an 11th magnitude spiral with a majestic three-armed spiral pattern. Its large, nearly circular shape spanning 10.0′ x 8.0′ gives it a fairly low surface brightness, but its bright core is visible in any telescope. Southeast of NGC-4395 are two very unusual galaxies lying within the same low-power telescopic field. These are **NGC-4631**, an edge-on spiral galaxy, and **NGC-4656**, a bizarre irregular system. NGC-4631 glows at magnitude 9.7 in an area measuring 12.5′ x 1.2′. Though it is believed to be a normal Sc-type galaxy, NGC-4631's edge-on perspective shows us immense amounts of dust and knotty clumps of material on the periphery of its disk. The largest backyard telescopes show little more than mottling, but they do show a tiny fuzzball just off NGC-4631 — this is NGC-4627, a tiny satellite galaxy. NGC-4656, a huge galaxy covering 19.5′ x 2.0′ and glowing at 11th magnitude, resembles M-106 in the smallest instruments. An 8-inch telescope shows mottling and uneven illumination across the face of this object, and also reveals that one end is "hooked." This high distortion is unexplained at the moment.

Two small galaxies in the central part of the constellation are **NGC-5005** and **NGC-5033**. NGC-5005 is an 11th magnitude spiral covering 4.7′ x 1.6′ of sky. NGC-5033 shines at the same magnitude and is the same type of galaxy, but is larger by a factor of two.

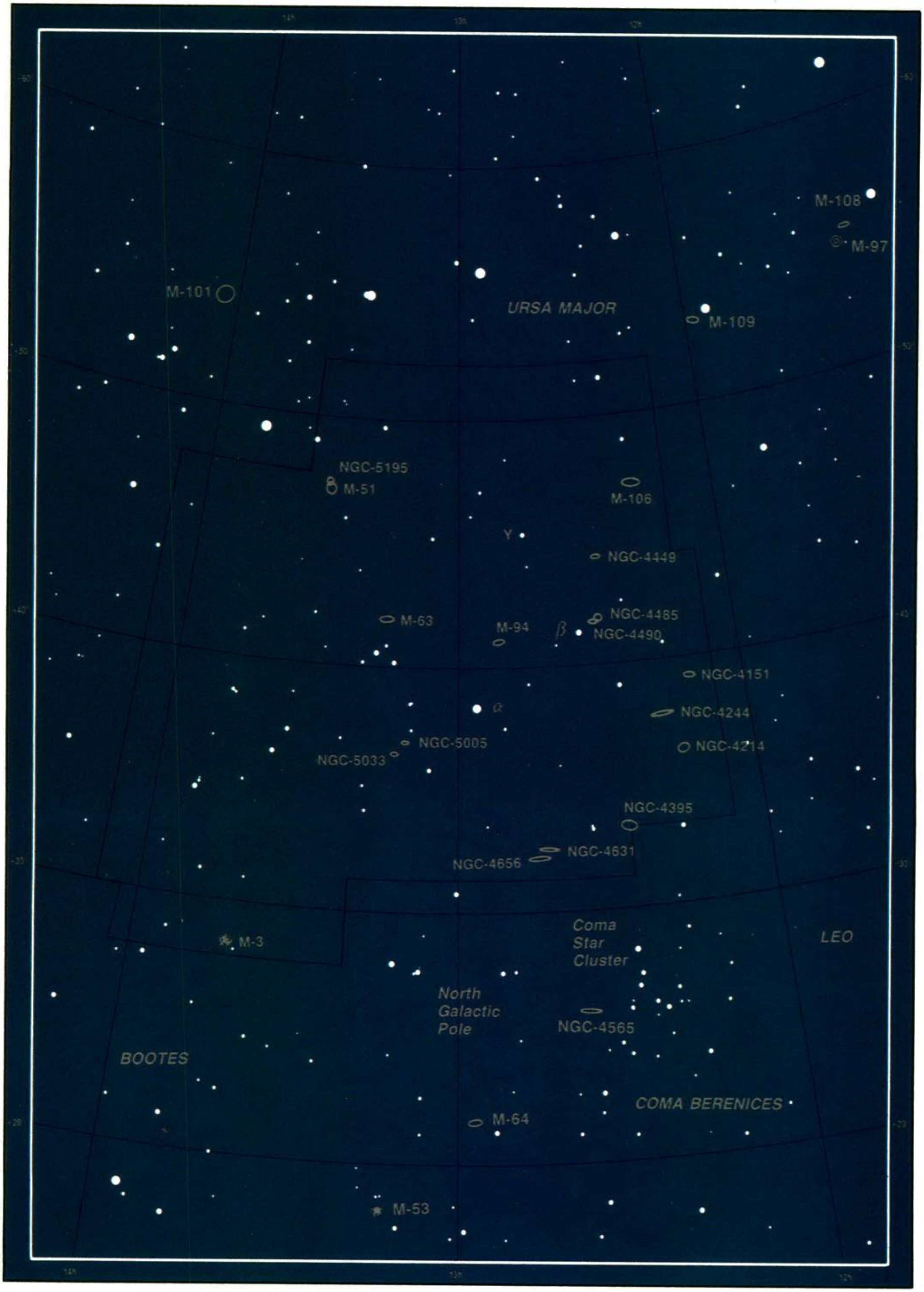
One of spring's finest double stars for small telescopes is **Cor Caroli**, also known as Alpha (*α*) Canum Venaticorum, 12 Canum Venaticorum, and Σ1692. (Cor Caroli means "Heart of Charles," named in honor of the "martyr" King Charles I of England and his son Charles II, who was restored to the throne.) This fine pair is composed of magnitude 3.0 and 5.5 stars separated by 19.6″ in p.a. 228° (it is relatively fixed). The stars appear bluish-white and white, and are easily resolved at moderate powers in virtually all telescopes.

Although galaxies are scattered all over Canes Venatici, there is at least one spectacular object located closer to home — globular cluster **M-3** (NGC-5272). This magnificent ball of perhaps a million stars lies in the southeastern part of Canes Venatici, practically on Bootes' border. Binoculars show M-3 as a hazy spot, unlike the bright stars that surround it. A 3-inch telescope under good conditions will show a hazy disk of mottled light. Larger telescopes show individual stars at the edges of the cluster, and a 12-inch instrument under black skies will resolve M-3 into its core.

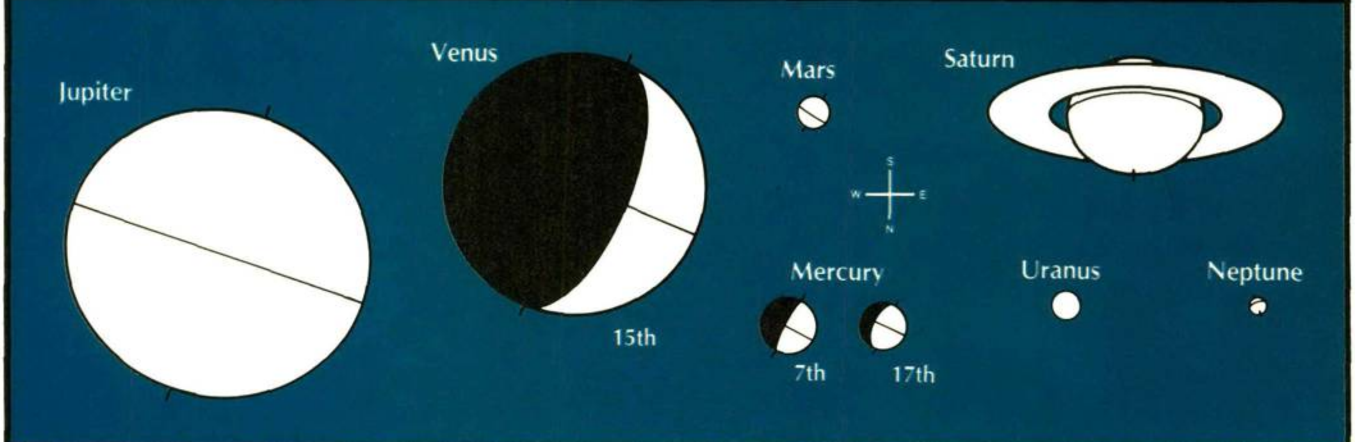
Object	M#	Type	R.A. (2000)	Dec.	Mag.	Size/Sep./Per.	H
NGC-4151		§B	12h 10.5m	+39°24′	11.2	2.5′x1.6′	SB
NGC-4212		#	12h 15.6m	+36°19′	10.5	7.0′x4.5′	I
NGC-4244		§	12h 17.5m	+37°48′	10.7	13.0′x1.0′	Sb
NGC-4258	M-106	§	12h 18.9m	+47°18′	9.0	19.5′x6.5′	Sb
NGC-4395		§	12h 25.8m	+33°32′	11.0	10.0′x8.0′	S
NGC-4449		#	12h 28.2m	+44°05′	10.5	4.2′x3.0′	I
NGC-4485		#	12h 30.7m	+41°41′	12.5	1.3′x0.7′	I
NGC-4490		§	12h 30.7m	+41°38′	10.1	5.0′x2.0′	Sc
NGC-4631		§	12h 42.2m	+32°33′	9.7	12.5′x1.2′	Sc?
NGC-4656		#	12h 44.0m	+32°10′	11.0	19.5′x2.0′	Ipec
NGC-4736	M-94	§	12h 50.9m	+41°07′	8.9	5.0′x3.5′	Sb
Cor Caroli (*α*)		★^{2}	12h 56.2m	+38°19′	3.0,5.5	19.6″	
NGC-5005		§	13h 10.8m	+37°03′	10.8	4.7′x1.6′	Sb
NGC-5033		§	13h 13.5m	+36°35′	11.0	8.0′x4.0′	Sb
NGC-5055	M-63	§	13h 15.8m	+42°01′	9.8	9.0′x4.0′	Sb
NGC-5194	M-51	§	13h 29.9m	+47°12′	8.7	10.0′x5.5′	Sc
NGC-5195		#	13h 30.0m	+47°16′	11.0	2.0′x1.5′	I?
NGC-5272	M-3	●	13h 42.2m	+28°23′	6.0	18′	

H = Hubble classification type for galaxies

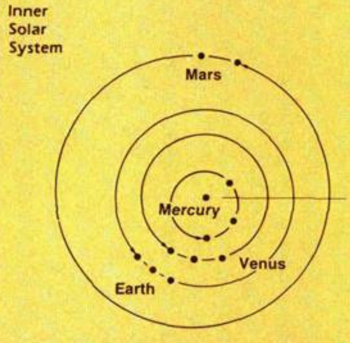
★^{2}	*Double Star*
●	*Globular Star Cluster*
§	*Spiral Galaxy*
§B	*Barred Spiral Galaxy*
#	*Peculiar/Irregular Galaxy*

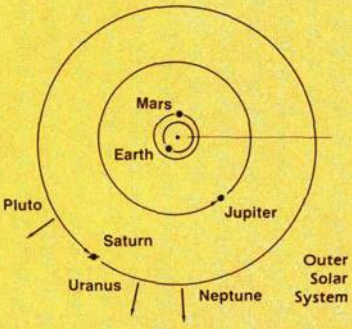

14h
13h
12h
+60°
+60°
M-108
M-97
M-101
URSA MAJOR
M-109
+50°
+50°
NGC-5195
M-51
M-106
γ
NGC-4449
+40°
+40°
M-63
M-94
β
NGC-4485
NGC-4490
NGC-4151
α
NGC-4244
NGC-5005
NGC-5033
NGC-4214
NGC-4395
NGC-4631
NGC-4656
+30°
+30°
Coma
Star
Cluster
LEO
M-3
North
Galactic
Pole
NGC-4565
BOOTES
COMA BERENICES
M-64
+20°
+20°
M-53
14h
13h
12h

Planetary Data May 1985


Jupiter
Venus
15th
Mars
Saturn
S
W
E
N
Mercury
7th
17th
Uranus
Neptune

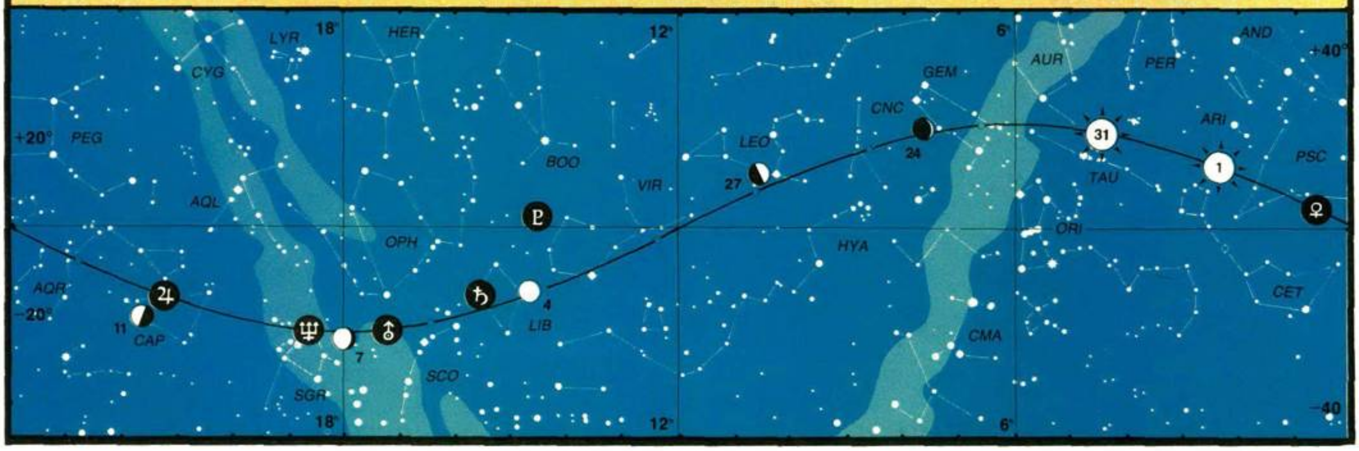
		Date	Mag.	Angular Size	% Illum.	Distance (AU) from: Earth	Distance (AU) from: Sun	Longitude: Heliocentric	Longitude: Ecliptic	R.A. (2000.0)	Dec.
Sun		1	−26.7	31.8′	—	1.01	—	—	40°34.7′	2h 32.4m	15°03.3′
		15	−26.7	31.7′	—	1.01	—	—	54°07.2′	3h 27.8m	18°51.1′
		31	−26.7	31.6′	—	1.01	—	—	69°30.2′	4h 32.2m	21°54.5′
Mercury	☿	1	0.5	8.1″	42%	0.83	0.46	274°40.4′	14°08.3′	0h 56.1m	2°55.3′
		15	−0.1	6.4″	65%	1.05	0.41	318°22.9′	31°35.4′	2h 01.5m	9°27.6′
		31	−1.4	5.2″	93%	1.28	0.32	30°43.8′	60°38.3′	3h 54.1m	19°45.0′
Venus	♀	1	−4.5	44.0″	19%	0.40	0.72	237°32.3′	7°18.3′	0h 21.9m	4°40.5′
		15	−4.5	35.1″	31%	0.48	0.73	259°47.7′	12°52.2′	0h 47.8m	4°48.6′
		31	−4.4	27.9″	42%	0.60	0.73	285°07.5′	24°46.0′	1h 34.2m	7°42.2′
Mars	♂	10	1.6	3.8″	99%	2.46	1.55	82°21.6′	69°37.0′	4h 31.4m	22°31.3′
		20	1.6	3.7″	99%	2.50	1.56	87°21.0′	76°26.7′	5h 00.8m	23°27.5′
Jupiter	♃	15	−2.4	40.4″	99%	4.87	5.11	304°58.7′	316°29.3′	21h 16.5m	−16°26.6′
Saturn	♄	15	0.0	18.5″	100%	8.92	9.93	234°48.6′	235°05.5′	15h 33.4m	−16°44.7′
Uranus	⛢	15	5.5	3.9″	100%	18.14	19.08	255°43.1′	257°05.9′	17h 03.9m	−22°50.5′
Neptune	♆	15	7.9	2.3″	100%	29.46	30.25	272°00.1′	273°24.8′	18h 14.8m	−22°14.4′
Pluto	♇	15	13.7	0.1″	100%	28.87	29.77	213°30.7′	212°58.6′	14h 26.4m	3°43.9′


Inner Solar System
Mars
Mercury
Venus
Earth


Mars
Earth
Jupiter
Pluto
Saturn
Uranus
Neptune
Outer Solar System

Moon Data

Full Moon	May 4 at 19h53m
Last Quarter	May 11 at 17h34m
New Moon	May 19 at 21h41m
First Quarter	May 27 at 12h56m
Full Moon	June 3 at 3h50m
Last Quarter	June 10 at 8h19m
Perigee: May 4 at 5h23m	357,622 km.
Apogee: May 16 at 23h50m	406,103 km.


LYR
18ʰ
HER
12ʰ
6ʰ
AND
+40°
CYG
GEM
AUR
PER
CNC
ARI
+20°
PEG
LEO
31
BOO
24
1
PSC
27
TAU
VIR
AQL
ORI
HYA
OPH
AQR
CET
−20°
4
11
CAP
LIB
7
CMA
SCO
SGR
18ʰ
12ʰ
6ʰ
−40

Star trails over a star party — observing weather returns! Hey, wait a minute — where's Polaris? This star party's Down Under, mate, and those are southern star trails! Photo by Jim Barclay of Queensland, Australia.

Mercury

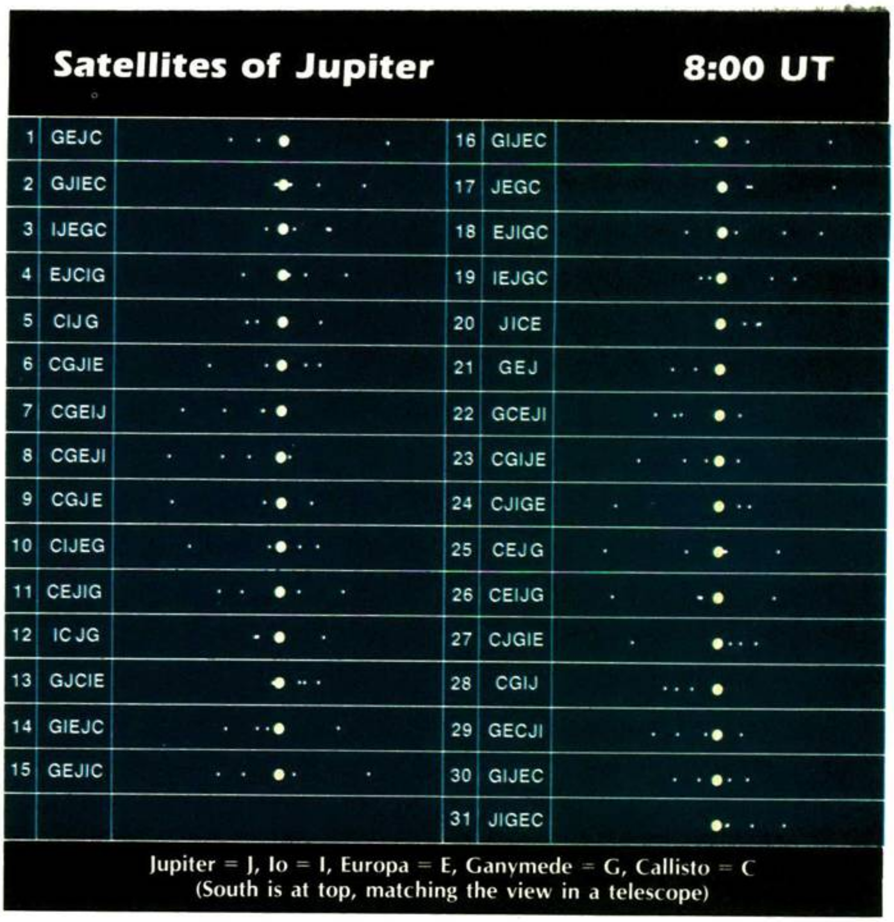
On May 1st, Mercury reaches greatest western elongation. Although the planet is some 27° west of the Sun in the morning sky, this apparition offers very poor viewing conditions. At highest elevation during the first week of May, the little planet won't be more than about 2° above the eastern horizon 45 minutes before sunrise.

Venus

Mercury's companion in the morning sky, Venus, is easier to find, being brighter and a good deal higher. During May, Venus will retain its crescent phase, but by mid-June it will become half-lit. The easiest way to observe the bright planet is to center your scope on it while it is relatively low, then keep observing as it rises and dawn lightens the sky. Just before sunrise, the planet should stand out nicely against a deep-blue sky and have high enough elevation to minimize the bad seeing near the horizon.

Moon

Two eclipses occur this month — a total lunar eclipse on May 4th and a partial



solar eclipse on May 19th — but neither will be visible to most ASTRONOMY readers.

The May 4th lunar eclipse is visible from Africa, Asia, and the western Pacific Ocean. During the eclipse (maximum magnitude of 1.243 at 19h56m UT), the bright double star α Librae (Zubenelgenubi) is occulted.

On the 19th, the Moon passes across the solar disk, but the tip of the Moon's shadow is too far out from Earth and, in any case, passes to the north of our planet. The result is a partial solar eclipse (maximum extent 84.1%) visible mainly from the northern polar regions.

The southern limit runs east-northeast across North America from about latitude 55° north on the Pacific coast. It reaches highest latitude (about 57° N) at around longitude 110° west in northern Canada, then turns southeastward, descending in latitude to cut across James Bay and the St. Lawrence River near Quebec City. The northern end of Nova Scotia and all of Newfoundland, Greenland, and Iceland lie within the limit. The eclipse begins at 19h15m, reaches maximum at 21h29m, and ends at 23h42m.

Mars

Although conjunction with the Sun doesn't come until July 18th, the Red Planet has all but vanished into the evening twilight. It is visible low in the west-northwest right after sunset, but sets soon after.

Asteroids

1 Ceres (magnitude 8.5) is moving eastward in northern Taurus. Its positions:

10th: 5h 04m 00s, 23° 45.5′
20th: 5h 21m 59s, 24° 23.5′

Ceres sets around 10 p.m. local daylight time on the 15th.

2 Pallas was in conjunction with the Sun on April 5th; now near the variable star Mira in the tail of Cetus, Pallas lies well south of the ecliptic and won't be visible in the morning sky until June.

3 Juno (10.1) is nearly stationary in western Virgo for the whole month of May. Its positions:

10th: 12h 02m 23s, 6° 54.5′
20th: 12h 01m 55s, 7° 04.5′

Juno sets around 5 a.m. local daylight at mid-month.

4 Vesta (5.9) is also in Virgo, but about 10° to the northeast of Spica. Its positions:

10th: 13h 46m 37s, 1° 34.1′
20th: 13h 40m 14s, 1° 23.5′

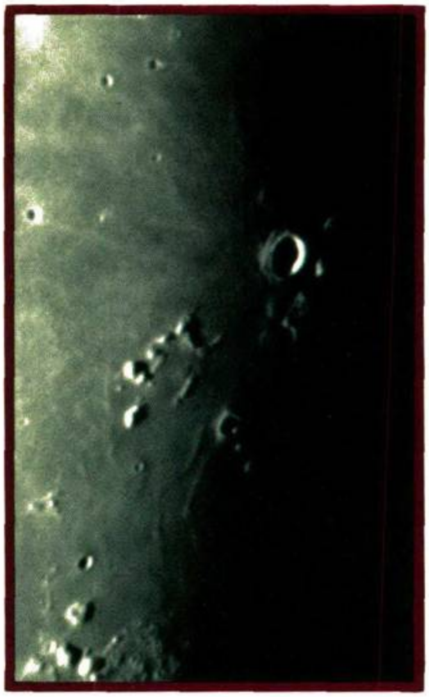
Vesta sets about 5:30 a.m. local daylight on the 15th.

For convenience in plotting their motions on a star atlas, all asteroid coordinates are for the epoch 2000.0.

Jupiter

Starting in late May, the Earth lies very close to the plane of Jupiter's equator. This means that from our viewpoint, its moons will occult or eclipse each other on occasion. Not all these events are visible with a telescope, and not all are well-timed for western hemisphere observers.

For example, on May 27th between 8h09m and 8h13m UT, Ganymede will partially occult Io; the change in brightness, however, is only 0.03 magnitude — undetectable by eye no matter how large your telescope. A better event occurs three days later on the 30th, when between 10h25m and 10h53m UT Europa will partially occult Callisto. The pair will be 3.6 Jupiter radii from the center of the planet. The dip in brightness is 0.16 magnitude — small but perceptible with at least a medium-sized backyard telescope.



Right: This month's "Best Astro-Photo" award goes to Mace Hooley, whose photo captured Gemini's M-35 and NGC-2158 (top) and *IC* 443 and NGC-2174/75 (bottom). Hooley used an 8-inch f/1.5 Schmidt camera, exposing Fujichrome *100 film through a 50CC magenta filter and* processing it as a negative. Left: Sunrise at Aristarchus — David Mansbridge photo *(8-inch SCT, eyepiece projection to f/1000,* 1.5 seconds on Ilford FP4).

Saturn

Saturn reaches opposition on May 15th, when, at zero magnitude, it will display a ball 18.5″ of arc across. The rings (tipped 23°) will be 42″ across. As noted in Eye on the Sky, Saturn will pass close to two sixth-magnitude stars: ζ Librae on the 16th and 34 Librae on the 23rd. Low to moderate eyepiece powers will give the best views, and it might be fun to do a sequence of sketches showing the motion of Saturn. (Photographing the encounters will be more difficult than sketching, given the magnitude difference between Saturn and the stars.)

Compared to Jupiter's, Saturn's cloud belts are substantially more difficult to see — many a beginner, looking into his scope's eyepiece and seeing a featureless buttermilk disk, is certain it has none. Yet although pale, they are present — and often a few weeks of observing practice reveals them.

Another useful method is to view the planet through a filter. Try holding a photographic filter over the eyepiece while viewing. Two standard black-and-white filters are probably the most useful: red and blue. A Wratten #25 (red) darkens any bluish-tinted features, while a #47 (blue) brings out striping near the equatorial belts. Also look for small white ovals in the yellowish equatorial zone — but don't expect to spot many, they're rare!

Uranus

During the first half of May, retrograding Uranus will lie several minutes of arc to the south of a 10th magnitude globular cluster, NGC-6287. Uranus is easy to locate using the finder chart in the January 1985 issue — and it is immediately recognizable with low to medium magnifications. It has a greenish-blue disk that appears surprisingly bright and non-stellar.

Neptune

Neptune is a near-twin to Uranus, but since it lies 11.32 astronomical units farther away from us (1.7 billion kilometers), Neptune looks smaller, greyer, and less bright. In the rich Milky Way starfields of Sagittarius, Neptune lies a little over a degree south of the 3.9 magnitude star μ Sagittarii (see the finder chart in the January issue).

Pluto

Pluto has two close appulses this month. On May 1st, it passes 1′37″ north of 7.9 magnitude SAO 120474. Then on May 8th, it misses SAO 120466 by 44″, passing north of the 8.5 magnitude star. SAO 120466 is plotted on chart 14 of the *Sky Atlas 2000.0*, five millimeters to the northwest of galaxy NGC-5638; it is the fainter of the two stars plotted there. Pluto is at 14th magnitude and requires at least an 8-inch telescope to be seen.

Meteors

May's best meteor shower is the Eta Aquarid, spawned from Comet Halley. This is the last apparition of the shower before the comet itself returns — unfortunately, the Moon could hardly be worse. Peak activity is the night of May 4th to 5th, the same day as Full Moon. Even so, look for meteors if it's clear. The Halley Watch needs information on the shower, so do your best! Send reports to International Halley Watch, Jet Propulsion Laboratory, 4800 Oak Grove Dr., Pasadena, CA 91109.

Comet Halley

The comet is now in Taurus, just over the invisible border from Orion. It is moving eastward slowly, but picking up speed as it heads for conjunction with the Sun on June 11th. Its positions (2000.0 epoch):

10th: 5h 02m 03m, 16° 30.7′
20th: 5h 06m 52m, 16° 53.9′

On the 15th, Halley is 4.87 AUs away from us and at magnitude 15.6.

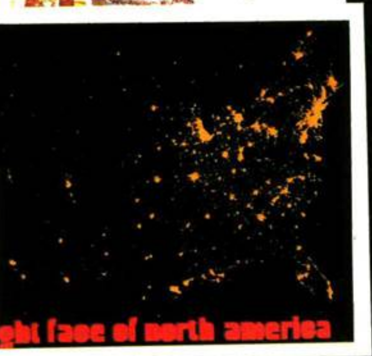
ASTRONOMY'S

POSTER GALLERY

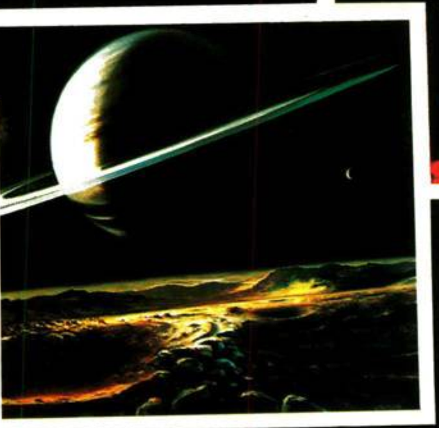
To order, write poster name and artist on the AstroMedia order form bound into this magazine or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202. All posters are in stock for immediate delivery, and will be shipped in sturdy containers to arrive intact and ready to hang.

Space Shuttle
NASA Facts
United States
NASA

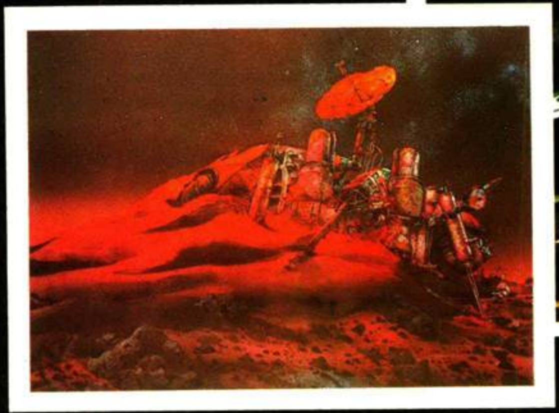
Space Shuttle by NASA: 30″ x 42″ $4.95
A giant poster, revealing fine detail, complete with specs.



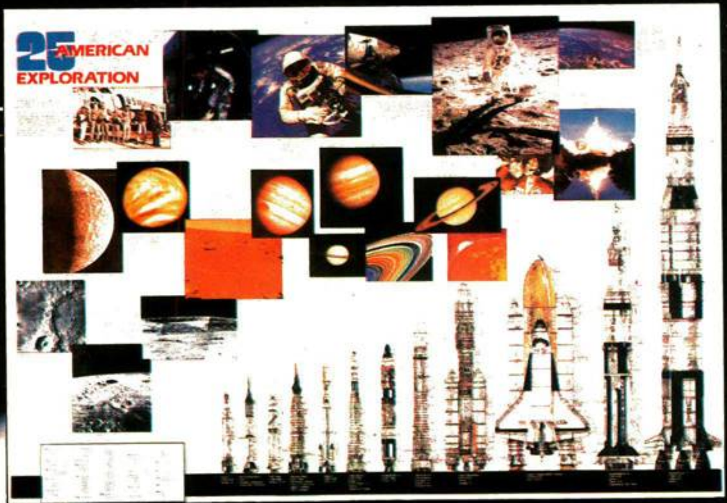
Night Face of North America: 17″ x 22″ $3.95
Shows the lights of every city over 5,000 in the Unites States. Find your home town!



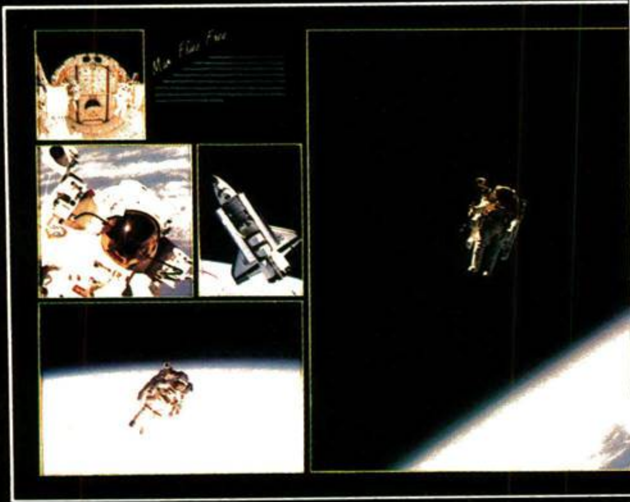
Saturn: 22″ x 34″ $12.00
Ringed Saturn looms above a rocky moon in this superior reproduction of John Clark's work commissioned by ASTRONOMY.



Viking at Mars: 24″ x 36″ $7.95
Artist Bruce Bond captures our pioneer spirit in this illustration of how Viking 1 might look thousands of years from now.



25 Years of American Space Exploration: 21″ x 30″ $4.95
Filled with facts and photos — highlights all of NASA's major achievements of the last quarter century.



Man Flies Free: 21″ x 30″ $4.95
Commemorates the first untethered space walk in history!

CELESTRON:
THE BEST IS NOW THE MOST BEAUTIFUL

When they were introduced, Celestron's line of catadioptric telescopes captured the minds and hearts of amateur astronomers everywhere. They provided excellent images. With crisp resolution. Color-perfect optics. And best of all, they were extremely compact, portable and reasonably priced.

Celestron's C90, C5, C8, C11 and C14 quickly became the standard by which all others were judged. While imitators have appeared, Celestron has quietly—and superbly—refined the line. Computer-designed optics and laser-testing were enhanced. Special starbright coatings were added. New finderscopes and mounts became available. Even an ultra-precise Byers worm gear drive base was specially developed. The instruments became so astronomically refined, Celestron offered a limited lifetime warranty.

Then—and only then—have we turned our attention to making the best also the most beautiful. See for yourself—instruments that now capture the minds, hearts and eyes of amateur astronomers everywhere.

For Dealer Locations, Catalogs, Information, Technical Data Sheets

CALL FREE 1-800-421-1526
(Mon-Fri; 8-4:00 Pacific Time; Continental USA only)

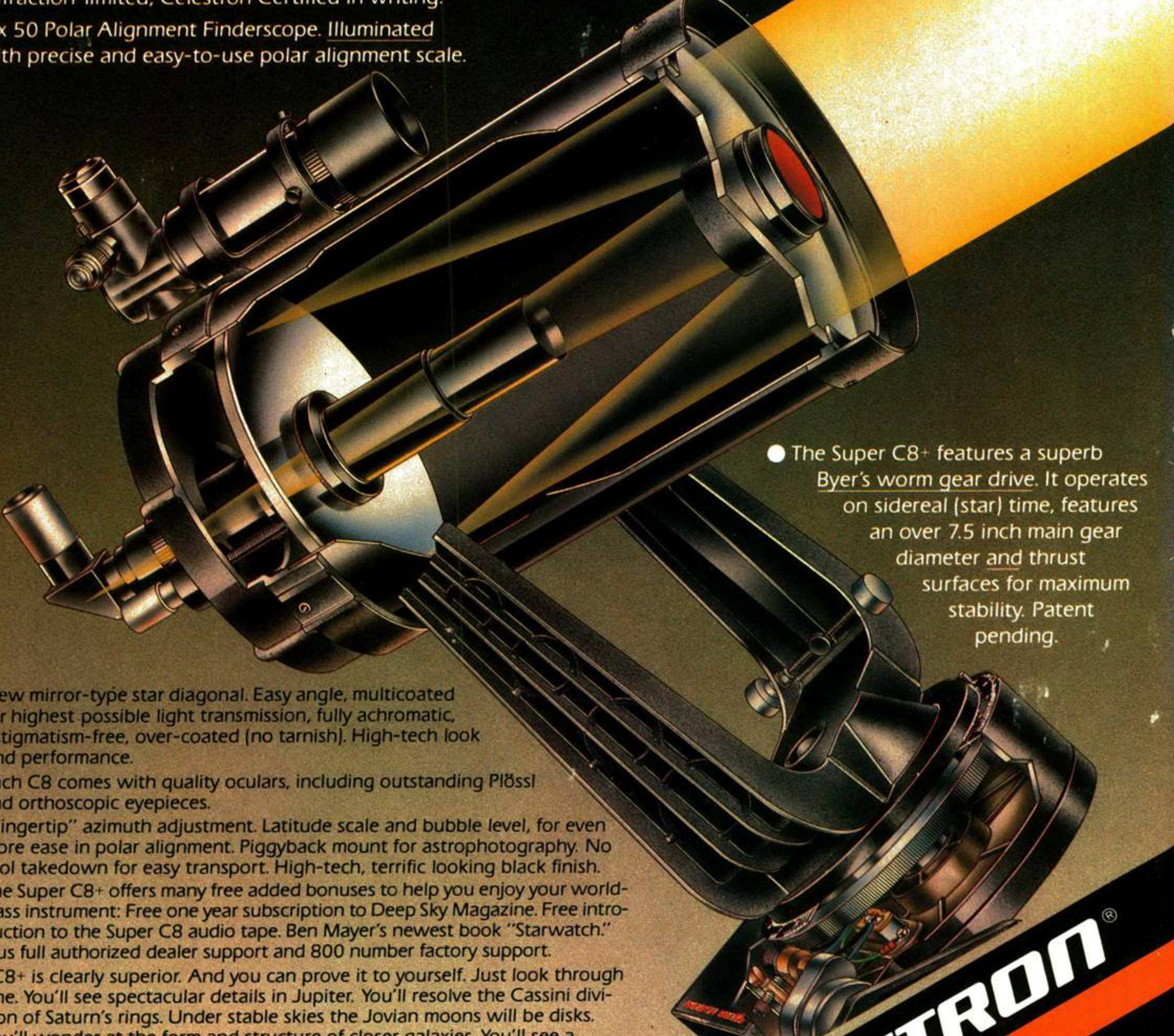
CELESTRON INTERNATIONAL
P.O. Box 3578B5A
2835 Columbia St.
Torrance, CA 90503
(213) 328-9560

CELESTRON®
PRECISION OPTICS

10 REASONS TO LOOK INTO OUR SUPER C8+

The SC8+ is clearly the most advanced instrument in its class.

- Celestron developed Schmidt-Cassegrain design means bright, f/10 images and incredible portability in a powerful 2,000mm focal length telescope... with a huge 8 inch aperture.
- Celestron hand polishes and matches, then laser tests each SC8+ optical system. All optics are diffraction-limited, Celestron Certified in writing.
- 8 x 50 Polar Alignment Finderscope. Illuminated with precise and easy-to-use polar alignment scale.
- Both mirror surfaces can be Starbright coated for the brightest and highest contrast images possible. (option)



- The Super C8+ features a superb Byer's worm gear drive. It operates on sidereal (star) time, features an over 7.5 inch main gear diameter and thrust surfaces for maximum stability. Patent pending.
- New mirror-type star diagonal. Easy angle, multicoated for highest possible light transmission, fully achromatic, astigmatism-free, over-coated (no tarnish). High-tech look and performance.
- Each C8 comes with quality oculars, including outstanding Plössl and orthoscopic eyepieces.
- "Fingertip" azimuth adjustment. Latitude scale and bubble level, for even more ease in polar alignment. Piggyback mount for astrophotography. No tool takedown for easy transport. High-tech, terrific looking black finish.
- The Super C8+ offers many free added bonuses to help you enjoy your world-class instrument: Free one year subscription to Deep Sky Magazine. Free introduction to the Super C8 audio tape. Ben Mayer's newest book "Starwatch." Plus full authorized dealer support and 800 number factory support.
- SC8+ is clearly superior. And you can prove it to yourself. Just look through one. You'll see spectacular details in Jupiter. You'll resolve the Cassini division of Saturn's rings. Under stable skies the Jovian moons will be disks. You'll wonder at the form and structure of closer galaxies. You'll see a swarm of filaments that fill your eyepiece when you view the Orion nebula. You'll be convinced. Which, of course, is why more people buy Celestron 8's than any other instrument in its class in the world.

For Dealer Locations, Information, Technical Data Sheets
CALL FREE 1-800-421-1526
(Mon-Fri; 8-4:00 Pacific Time; Continental USA only)

CELESTRON INTERNATIONAL
P.O. Box 3578B5, 2835 Columbia Street
Torrance, CA 90503 (213) 328-9560

CELESTRON®
PRECISION OPTICS